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Thinking Together: New Forms of Thought System for a Revolution in Military Affairs

Martin Burke

DSTO-RR-0173

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Joint Systems Branch
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ABSTRACT

The notion of Thought Warfare and Anti-Warfare (TWAW) is introduced as a way of thinking about military conflict and its avoidance; it is foreseen as an increasingly important Defence issue in the twenty-first century. TWAW involves the dynamic interaction of allies' and adversaries' Thought Systems. Current Thought Systems involve entities capable of cognition, emotion and volition - typically (groups of) people - interacting via networks of information and data systems. New forms of Thought System are proposed that go beyond this; if realised they could provide significant comparative advantage in TWAW and may contribute to a Revolution in Military Affairs.

RELEASE LIMITATION

Approved for public release

DEPARTMENT OF DEFENCE
DEFENCE SCIENCE & TECHNOLOGY ORGANISATION
DSTO

Published by

DSTO
Electronics and Surveillance Research Laboratory
PO Box 1500
Salisbury South Australia 5108

Telephone: (08) 259 5555
Fax: (08) 259 6567

AR No. AR-011-473
July 2000

Thinking Together: New Forms of Thought System for a Revolution in Military Affairs

Executive Summary

'All things are ready, if our minds be so.'

King Henry the Fifth
(Act IV, Scene III)
William Shakespeare

Toffler and Toffler have introduced the notion of War and Anti-War as a new way of thinking about military conflict and its avoidance, [Toffler and Toffler 1993]. They foresee that advances in information and telecommunications technologies will lead to Knowledge Warfare and Anti-Warfare (KWAW) being the pre-eminent Defence issue in the twenty-first century. They introduce the idea of Thinking Systems as entities in which groups of people act as knowledge agents supported by networks of information and data systems. They discuss how KWAW concerns the interaction of allies' and adversaries' Thinking Systems.

This paper addresses the same domain as Toffler and Toffler. However, by adopting an architectural perspective, it conceptualises the domain in a markedly different way; this affords various significant new insights that are of potential Defence significance.

Within this perspective, Thought Systems (TS) are proposed as being broadly equivalent to the Tofflers' Thinking Systems. Thought Systems are considered to consist of five principal types of components namely: Data Systems (DS), Information Systems (IS), Knowledge Systems (KS), Will Systems (WS) and Feeling Systems (FS).

Furthermore, within this perspective, the term Knowledge Warfare and Anti-Warfare is seen to be a misleadingly narrow term for the domain to which it refers. The term Thought Warfare and Anti-Warfare (TWAW) is regarded as being more appropriate since it captures not just the cognitive aspects of the domain but also the emotional and volitional aspects.

This paper suggests that the goal in synthesising Thought Systems is to achieve synergy in the sense that the "capability" of a Thought System, denoted C(TS), is greater than the sum of the capabilities of its component Data Systems, Information Systems, Knowledge Systems, Will Systems and Feeling Systems, denoted C(DS), C(IS), C(KS), C(WS), and C(FS) respectively. That is:

$$C(TS) > C(FS) + C(WS) + C(KS) + C(IS) + C(DS)$$

The paper presents a provisional conceptualisation of the domain of TWAW using plain English and simple architectural techniques; the conceptualisation is used to frame an analysis of current Thought Systems in Defence. It suggests that current Defence capability

development focuses on Data Systems and Information Systems. Very little explicit thought and action is devoted to Knowledge Systems, Will Systems or Feeling Systems; the goal of achieving synergy through their interaction is largely overlooked. This is exemplified by Defence's recent initiatives with the Defence Information Environment (DIE), [Chin 1999], [Burns 2000]; Takari, [Chessell 1997], [Takari 2000]; and Project Sphinx, [DFW 1999].

In the assumption that in the future Australia's likely adversaries will have superior numbers, similar technology and can potentially have access to the same information (ie information security cannot be assured) it argues that the onus in future TWAW will be on Knowledge Systems, Will Systems and Feeling Systems.

It argues that major comparative advantage in TWAW can be anticipated if new types of Thought Systems can be realised. It suggests how this would contribute to a Revolution in Military Affairs (RMA), [ORMA 1999], through step-changes in C(KS) rather than C(IS) or C(DS). Comments are also made about developments in C(WS) and C(FS).

The paper proposes various new types of Thought System; new modes of cognition and consciousness emerge as properties of these systems. It discusses the Defence implications of these ideas and outlines a research program by which they might be developed further.

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Martin Burke holds the position of Architecture Mentor in Joint Systems Branch where he conducts research in the emerging fields of Thought Systems, Architecture Meta-Thinking and Multi-Disciplinary Thinking. He is also an Adjunct Senior Research Fellow at the Systems Engineering and Evaluation Centre at the University of South Australia and an Associate of the Centre for Business Dynamics and Knowledge Management at the Australian Defence Force Academy, University of New South Wales.

At other stages of his career, Martin has held research and management positions in ITD's Information Architectures Group, ITD's Software Systems Engineering Group, the UK Atomic Energy Authority, the SEMA Group Research Centre and Rolls Royce (Aero).

Martin has a BSc (Hons) in Physics, a MSc in Mathematical Statistics and a PhD in Engineering Mathematics.

Contents

1 Introduction

'Some men see things as they are and ask why; others dream of things as they might be and ask why not.'

Robert Kennedy

1.1 Context

This paper is an output of a research effort initiated within the Joint Systems Branch of DSTO. It has been carried out as part of DSTO Task JNT 99/018 (Architecture Support and Technology). Dr Michael Jarvis of the Capability Analysis Staff has been the primary point of contact in Australian Defence Headquarters for the work.

1.2 Readership

The paper has been written to be read by members of the Australian Defence community particularly those concerned with "alternate futures" and long-term strategic planning. It assumes that the reader is familiar with concepts such as the Revolution in Military Affairs, (RMA), Knowledge Warfare, C4ISREW, etc. No particular academic background has been assumed of its readership. All arguments developed in the paper are couched in terms of concepts that are introduced in the paper. Wherever possible, "plain English" is used.

A version of this paper has been prepared that uses a simple colour scheme in an attempt to facilitate it being read differently by readers with different professional interests, cognitive styles, time available for reading it, etc. In particular, it supports readers wishing to gain just a basic grasp of the paper's major ideas. This colour version is available on the DSTO Scientific and Technical Publications Database at:

http://www.dsto.defence.gov.au/corporate/reports/DSTO-RR-0173.pdf

1.3 Background and Motivation

Toffler and Toffler have introduced the notion of War and Anti-War as a new way of thinking[1] about military conflict and its avoidance, [Toffler and Toffler 1993]. Their basic premises are that, in any epoch:

- the way that wealth is created strongly influences the way that war is made;
- different forms of warfighting require different forms of peacekeeping.

They contend that, broadly speaking, history can be divided into two epochs dominated by distinctly different forms of wealth creation and warfighting: an Agrarian Age characterised by the hoe and the sword; and an Industrial Age characterised by mass production and mass destruction. They argue that, as information and knowledge become the core of advanced economies, the transition into a third epoch, the Information (or Knowledge) Age, will occur. They forecast that information and knowledge strategies will

[1] Thomas Kuhn, [Kuhn 1996 (1962)], coined the term "paradigm shift" to refer to such changes in thinking.

increasingly dominate in business, warfighting and peacekeeping. They speculate on many issues including:

- the use of artificial forms of intelligence in military decision making;
- the use of precision genetic weaponry in attacking specific ethnic or racial groups;
- the use of virtual reality weapons in confusing enemies;
- the use of electronic "ants" in penetrating business and military computer systems;
- the use of digital media as an alternative to traditional means of diplomacy;
- the emergence of "Peace corporations" that profit by maintaining peace in assigned regions;
- the re-structuring of the United Nations to give various sorts of communities greater roles in "peace-fare".

They foresee that advances in information and telecommunications technologies will lead to Knowledge Warfare and Anti-Warfare (KWAW) being the pre-eminent Defence issue in the twenty-first century[2]. They introduced the idea of Thinking Systems as entities in which groups of people act as knowledge agents supported by networks of information and data systems. They discuss how KWAW concerns the interaction of allies' and adversaries' Thinking Systems.

The Zapatista "social netwar" in Mexico is a seminal case of KWAW. According to Ronfeldt et al., [Ronfeldt, Arquilla et al. 1998], the social netwar started in 1994 as a result of the guerilla-like insurgency of the Zapatista National Liberation Army (EZLN) against the Mexican government. The EZLN's small indigenous force started a violent insurrection in Chiapas, an isolated region of southern Mexico. They then declared war on the Mexican government, vowed to march on Mexico City, proclaimed a revolutionary agenda, began an international media campaign for sympathy and support, and invited foreign observers and monitors to come to Chiapas. The government's response was to order the army and police to suppress the insurrection and to downplay its size, scope and causes. This combination of events aroused a multitude of activists associated with a variety of non-governmental organisations (NGOs) from around the world to "swarm" electronically and physically. They linked up with Mexican NGOs to voice solidarity with the EZLN's demands and to press for non-violent change. The protagonists communicated, coordinated and conducted their campaign in an "internetted" manner and without a central command. Within a fortnight, Mexico's president called a halt to combat operations and agreed to enter negotiations including consideration of major democratic reforms. Over the next few years, a social netwar raged which, with very few violent side-effects, had profound repercussions for the Mexican political system. It was the first example of social netwar; its full implications for the future of KWAW have yet to be realised.

The current work has been motivated by the perception that the Tofflers' thinking, despite having identified and scoped an important domain, lacks coherence in some important respects. For example, it was judged that it would be difficult to provide a cogent

[2] Subsequent developments strongly suggest that this prediction is likely to be realised. For example, Australian Strategic Policy, [Defence 1997], identifies the "Knowledge Edge" as Australia's highest Defence priority and Joint Vision 2010, [DOD 1997] stresses the importance of "Information Superiority" in future warfighting involving the US Armed Forces.

description of the Zapatista social netwar using just the concepts introduced in the Tofflers' book. The following were considered to be important deficiencies in the Tofflers' thinking:

- failure to distinguish between the data, information, knowledge[3], will and feeling aspects of Thinking Systems and KWAW;
- failure to capture the nature of the inter-relationships of the data, information, knowledge, will and feeling aspects of Thinking Systems and KWAW.

It was considered likely that using an architectural approach to re-conceptualise the domain would afford a more coherent insight into the nature of the domain. Within this approach, Thought Systems (TS) are proposed as being broadly equivalent to the Tofflers' Thinking Systems. Thought Systems are considered to consist of five principal types of components namely: Data Systems (DS), Information Systems (IS), Knowledge Systems (KS), Will Systems (WS) and Feeling Systems (FS). Furthermore, the term Knowledge Warfare and Anti-Warfare is seen to be a misleadingly narrow term for the domain to which it refers. The term Thought Warfare and Anti-Warfare (TWAW) is regarded as being more appropriate since it captures not just the cognitive aspects of the domain but also the emotional and volitional aspects.

It was speculated that a coherent conceptualisation[4] of the TWAW domain would be valuable in various ways in the Defence context. For example, observation of recent Defence initiatives such as the Defence Information Environment (DIE), [Chin 1999], [Burns 2000]; Takari, [Chessell 1997], [Takari 2000]; and Project Sphinx, [DFW 1999] suggests that:

- current Defence capability development focuses on Data Systems and Information Systems;
- very little explicit thought and action is devoted to Knowledge Systems, Will Systems or Feeling Systems;
- the goal of achieving synergy through their interaction is largely overlooked.

Such initiatives appear to suffer from the lack a "big picture" that encompasses all of the important issues of TWAW. This suggests that a coherent conceptualisation of the TWAW domain would be a valuable immediate contribution to those involved with such initiatives. This in turn could be expected to promote the generation of further original ideas that could also be exploited in the Defence context.

In summary, the prospect is that the conceptualisation of the TWAW domain may provoke changes in thinking in the Defence community that are better suited to the development of Defence capability in an epoch of TWAW than those that prevail currently.

1.4 Scope and Objectives

The research has the following primary objective:

- to contribute to a Revolution in Military Affairs, (RMA), [ORMA 1999], by proposing new ways of thinking that may influence future military conflicts and their avoidance.

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[3] In an earlier work, [Toffler 1990], Toffler uses the words "data", "information", and "knowledge" interchangeably "to avoid tedious repetition"!

[4] In this work, the term "conceptualisation" is used to refer to "a system of ideas".

Secondary objectives derived from this are:

- to introduce the notion of Thought Warfare and Anti-Warfare (TWAW) as a generalisation of Knowledge Warfare and Anti-Warfare [Toffler and Toffler 1993].
- to begin the development of a coherent conceptualisation of the domain of TWAW;
- to propose new forms of Thought System that could provide significant comparative advantage in TWAW.

The objectives of this paper are:

- to present preliminary work that contributes to the research objectives and that identifies the key issues involved;
- to make proposals regarding how to make further progress;
- to promote discourse in the Defence community regarding its contents.

1.5 Approach

The approach adopted in pursuing the objectives has been strongly influenced by the following factors:

- the scope of the subject domain is enormously large and diverse;
- no single academic discipline "spans" the whole domain[5];
- the paper's primary audience will prefer that its ideas can be easily grasped and that they are expressed in non-technical terms;
- the paper's author is not expert in several important aspects of the domain.

Accordingly, the approach adopted has been one of creative but systematic multi-disciplinary thinking based upon a simple understanding of a relatively small number (approximately 35) of central concepts. The approach has been guided by Kline's *Conceptual Foundations for Multi-Disciplinary Thinking*, [Kline 1995], but does not comply with it in all respects. The approach uses architectural methods to deal with systems issues following the principles expounded by Burke in *Understanding Architecture*, [Burke 2000].

The approach aims to provide a crude but coherent conceptualisation of the subject domain that is adequate for preliminary (and suitably qualified) explanatory and predictive purposes and facilitates the proposal of new hypotheses. The basic intention is to give an impression of an emerging and rapidly changing subject that allows its major features to be distinguished and the nature of the change to be appreciated.[6]

It is emphasised that, since the paper's subject domain is fundamentally multi-disciplinary in nature, the approach does not attempt to comply with the conventions of any single discipline. Bearing this in mind, the approach aims to be academically sound; it does not, however, aspire to be scholastically rigorous. As a matter of practical necessity, there are

[5] Furthermore, the domain does not fall entirely within the boundaries of empirical science.

[6] In his book *The Quark and the Jaguar: Adventures in the Simple and the Complex*, [Gell-Mann 1994], the Nobel Laureate, Murray Gell-Mann, argues for "the need to overcome the idea, so prevalent in both academic and bureaucratic circles, that the only work worth taking seriously is highly detailed research in a specialty. We need to celebrate the equally vital contribution of those who dare to take what I call "a crude look at the whole." "

many aspects of the work that have been conjectured, invented or devised without the benefit of any prior knowledge other than that can be acquired by everyday experience or by reference to readily accessible texts. For example, no attempt has been made, in the first instance, to survey and review the extensive literature that relates to the concepts of cognition, consciousness etc. Instead, the "vulgar" and longstanding understandings of these concepts reflected by their definitions in the *Oxford English Dictionary*, [Sykes 1977], have been preferred initially. In subsequent refinements of this work, it may be appropriate to revise such aspects of the approach.

1.6 Structure

Apart from this Introduction, the paper is organised in 8 main Sections and 10 Appendices. The main body of the paper presents its primary arguments; it has a simple linear structure intended to promote it being read from "top to bottom". The Appendices provide detailed information or supplementary arguments; they are referred to from the paper's main body. Cross-references between Sections are also made. Footnotes are used to provide incidental information. The paper makes numerous references to sources other than itself using an [author, date] notation to index a References Section.

Section 2 introduces the central concepts from which a conceptualisation of TWAW can be developed. "Plain English" definitions of terms are provided wherever possible.

Section 3 introduces some simple architectural techniques used to frame the arguments made in subsequent Sections.

Section 4 provides insight into the prevailing architectural characteristics of current Thought Systems in terms of the typical characteristics and inter-relationships of their components.

Section 5 proposes several radically different new Thought Systems. It comments on their architectural characteristics, emergent properties and relative capabilities.

Section 6 discusses the Defence implications of the ideas presented earlier in the paper. It begins with a general discussion of the possible consequences of adopting an architectural approach in considering TWAW issues. It then discusses some specific instances in which the different ways of "thinking together" that have been envisaged could make an impact on Defence issues.

Section 7 outlines a research program to investigate new forms of Defence Thought System.

Section 8 draws together the various arguments made in preceding Sections.

Section 9 makes some brief concluding remarks.

The Acknowledgments Section thanks those who have contributed to the work.

The References Section contains a detailed listing of all external sources cited.

2 Central Concepts

'There is no exact usage of the word knowledge; but we can make up several such usages, which will more or less agree with the ways the word is actually used.'

Ludwig Wittgenstein

This Section introduces the central concepts involved in the paper. It provides:

- an overview of the inter-relationships of the concepts;
- succinct working "definitions" of the concepts expressed, wherever possible, in plain English;
- brief explanations of the concepts.

This approach has been adopted with the intention that the reader will, with minimal effort, be able to develop a coarse but coherent understanding of the concepts and their inter-relationships[7]. The primary aim of the approach is to assist the reader in developing an understanding of the distinguishing features of the concepts sufficient to grasp the nature of the arguments developed elsewhere in the paper. The approach is not intended to be scholastically rigorous. Although reference is made to some key complementary sources, full discussion of the academic literature pertaining to the concepts involved is considered to be inconsistent with the primary aim of the approach.

Note that some of the definitions are recursive in nature. That is, they define concepts in terms of simpler versions of those concepts. Recursive definitions are sometimes misleadingly thought of as being circular. The following way of thinking may be more helpful: a recursive definition is not circular but spiral; rather than defining a concept in terms of itself, it defines the concept in terms of simpler versions of itself.

2.1 Overview

Figures 1 and 2 and Table 1 provide an architectural overview of the inter-relationships of the concepts. They describe the concepts from three different perspectives thus providing a Synoptic View, a Structural View and a Piecewise View[8]. Appendix E defines and explains these Views.

[7] The reader is reminded that a version of this paper that uses a simple colour scheme in an attempt to facilitate it being read differently by people with different interests and needs is available on the DSTO Scientific and Technical Publications Database at:
http://www.dsto.defence.gov.au/corporate/reports/DSTO-RR-0173.pdf
Suggestions are made in that version regarding reading strategies that can be used to work through this Section.

[8] This is in keeping with Kline's hypothesis, [Kline 1995], that at least three views are needed for a reasonably good understanding of hierarchically structured systems with interfaces of mutual constraint: synoptic, piecewise and structural.

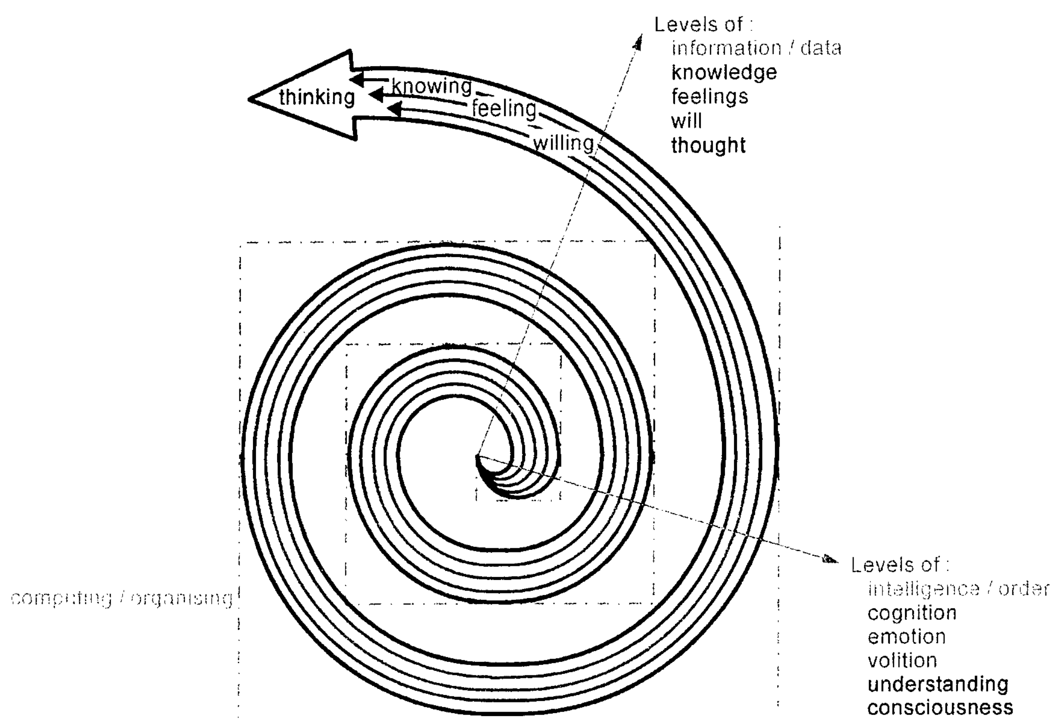

Figure 1 *Thought Systems: a Synoptic View*

A **system** is a **complex whole**.

The **architecture** of a system is what **we understand** about that **system**.

Data are **symbols** to which meaning has not been assigned.
A **Data System** deals with **data** by **organising**.
Order is the faculty of **organising**; it is an emergent property of a **Data System**.

Information is **symbols** to which **meaning** has been assigned.
An **Information System** deals with **information** by **computing**.
Intelligence is the faculty of **computing**; it is an emergent property of an **Information System.**

Knowledge is **meaning** derived from **information** and other **knowledge.**
A **Knowledge System** deals with **knowledge** by **knowing**.
Cognition is the faculty of **knowing**; it is an emergent property of a **Knowledge System**.

Feelings are **meaning** derived from **information** and other **feelings.**
A **Feeling System** deals with **feelings** by **feeling**.
Emotion is the faculty of **feeling**; it is an emergent property of a **Feeling System.**

Will is **meaning** derived from **information** and other **will.**
A **Will System** deals with **will** by **willing**.
Volition is the faculty of **willing**; it is an emergent property of a **Will System.**

Thought is **meaning** derived from **knowledge, will, feelings** and other **thoughts.**
A **Thought System** deals with **thoughts** by **thinking**.
Consciousness is the faculty of **thinking**; it is an emergent property of a **Thought System.**
Understanding is **assimilated thought**; it is an emergent property of a **Thought System.**

A **Culture** is the means by which a **group of Thought Systems** attempts to **share meaning.**

Figure 2 Thought Systems: a Structural View

System Type	Input Types	Output Type	Process	Emergent Properties
Data System	Data	Data	Organising: symbol processing	Order
Information System	Data; Information	Information	Computing: sign processing	Intelligence
Knowledge System	Data; Information; Knowledge	Knowledge	Knowing: schema processing	Cognition
Will System	Data; Information; Will	Will	Willing: schema processing	Volition
Feeling System	Data; Information; Feelings	Feelings	Feeling: schema processing	Emotion
Thought System	Data; Information; Knowledge; Will; Feelings; Thought	Thought	Thinking: schema processing	Consciousness Understanding

Table 1 *Thought Systems: a Piecewise View*

2.2 Definitions and Explanations

Definitions and explanations of the main concepts involved in the paper are provided below; both are deliberately succinct and, wherever possible, couched in colloquial language.

2.2.1 Meaning

Meaning is what is meant; it is the significance of thoughts, signs or actions in the context of the paradigms, cultures and environments in which they are generated, interpreted and used[9].

2.2.2 Symbol

A symbol is an entity that could be, but has not been, used to represent[10] meaning.

Symbols have the potential to represent both physical and conceptual entities.

2.2.3 Sign

A sign is an entity used to represent meaning.

Representing is the process by which meaning is assigned to a symbol to make a sign.

Interpreting is the process by which meaning is derived from signs.

Signs are used to represent both physical and conceptual entities.

As means of distinguishing between symbols and signs[11], consider the example of a red light. The light has the potential to have meaning assigned to it in various ways. Before meaning has been assigned to it, it is a symbol. When meaning is assigned to it becomes a sign. For instance, in different contexts, the red light is used to signify:

- the presence of danger;
- an instruction to stop;
- the port side of ship;
- the location of a brothel.

[9] See Edgar and Sedgwick, [Edgar and Sedgwick 1999], for a brief summary of the academic discourse concerning the nature of meaning. Also see Hall, [Hall 1997], Ayer, [Ayer 1967 (1946)], de Saussure, [Saussure 1983 (1916)], Kuhn, [Kuhn 1996 (1962)], the *early* Wittgenstein, [Wittgenstein 1961 (1921)], the *later* Wittgenstein, [Wittgenstein 1967 (1953)], Barthes, [Barthes 1964], Derrida, [Derrida 1978 (1967)], Foucault, [Foucault 1980],etc.

[10] See Hall, [Hall 1997], for a discussion of the concept of representation.

[11] See Hall, [Hall 1997], for a discussion of this distinction.

2.2.4 Schema

A schema is a conception[12] of what is common to the members of a set[13]; it is a mental sign.

Research has shown that schemata[14] are central in the way that people think and interact with the world, particularly about complex systems and problems[15]. The complexity of human schemata varies enormously ranging from the simplicity of labels used to identify objects to the extreme complexity of repertoires of relational ideas. Schemata may be learned or inherent. Examples of schemata include those involved in both learning and performing:

- language, eg words, grammar, etc;
- relatively simple composite tasks, eg walking, dressing, eating, etc;
- relatively complex tasks, eg typing, driving, playing musical instruments, medical diagnosis, conducting surgical procedures, etc
- problem solving, eg in chess, in physics, in mathematics, etc;
- creative activity, eg design, composition, innovation, speculation, theorisation, etc.

2.2.5 Schema Description

A schema description is a physical representation of a schema; it is a physical sign.

Examples of schema descriptions include:

- synopses;
- outlines;
- diagrams.

2.2.6 System

A system is a complex whole; an integrated entity of heterogeneous components that acts in a coordinated way.[16]

Figure 3, which is derived from [Flood and Jackson 1991], attempts to summarise the general conception of "system". Appendix I provides brief definitions and explanations of the main concepts relating to Systems of Systems, Joint Systems etc.

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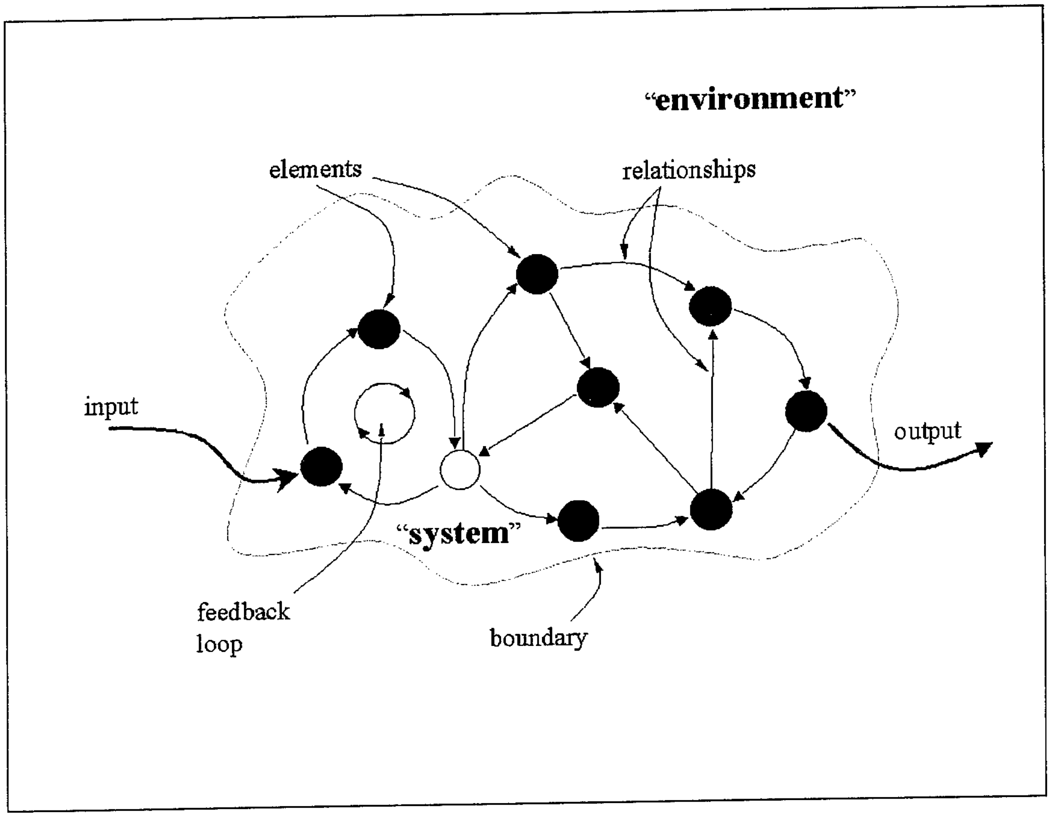
[12] In this work, the noun "conception", is used to refer to "that which has been formed in the mind".

[13] In this work, the term "set" is used to refer to "any well-defined list or collection of objects".

[14] Various different terms are used in the literature to label the schema concept. For example, Boulding, [Boulding 1956], uses the term "image".

[15] See Kline, [Kline 1995], for a discussion of this work.

[16] Multiple conceptions exist for the notion of system. Burke, [Burke 2000], addresses the diversity of these different ways of thinking; a review is made of the variety of definitions that have been made for the system concept; examples are provided from a selection of disciplines considered relevant in the Defence context. The suggestion is made that these different ways of thinking profoundly effect the practices and behaviour of their proponents when acting as individuals and as groups; an example from the Systems Engineering discipline is discussed.



Central concepts	Other concepts
element (or component)	attributes
relationship	transformation
boundary	purpose
input	open system
output	homeostasis
environment	emergence
feedback	communication
	control
	identity
	hierarchy

Figure 3 The General Conception of System, from Flood and Jackson, [Flood and Jackson 1991]

Kline, [Kline 1995], suggests that there are six major classes[17] of systems of concern to humankind. These are:

1. Inert, Naturally-Occurring Systems, eg rocks, air, ocean, weather, atoms, molecules, etc;
2. Artifactual Systems, eg tools, machines, structures, synthetic materials, socio-technical systems[18], socio-epistemo-technical systems[19], etc;
3. Biological Systems, eg organisms, ecologies, etc;
4. Human Systems, eg social, political, economic, aesthetic, affectional, etc;
5. Value Systems, eg ethnic, religious, intellectual, etc;
6. Communications Systems, eg language, writing, telecommunications, broadcasting, internet, etc.

2.2.7 Complexity

The complexity of a system, relative to an observer, is the length of the schema used by the observer to describe the system.[20]

2.2.8 Emergent Properties

An emergent property[21] of a system is a property that is meaningful when attributed to the whole system, not to its components.

Arguably, the key issue in the conception of system is that of emergence[22]. Emergence occurs when a system, created by integrating components into a complex whole, exhibits

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[17] In this work, the term "class" is used to refer to "a set whose members have some characteristic in common".

[18] In the sense that Kline uses the term, [Kline 1995], a "socio-technical system" should be understood to be "a complete system of coupled social and technical parts synthesised and used by humans to control their environment and to perform tasks that cannot be done otherwise". He argues that humankind has prospered (relative to other species) due to its ability to devise, build and use such systems. He maintains that the human powers created by socio-technical systems have increased at an accelerating pace for roughly the past two million years.

[19] Burke, [Burke 1999], observes that Kline's argument, although persuasive, omits (or at least chooses to de-emphasise) the role of <u>knowledge</u> in such human systems. Whereas Kline emphasises the benefits that groups of people derive by organising themselves in <u>social</u> groups to exploit <u>technology</u> in pursuance of their goals, Burke suggests that there are important classes of complex human systems that cannot be fully understood in this way. Burke advocates that, in addressing such systems, it is helpful to extend the socio-technical system conception to explicitly consider the interaction of knowledge. Burke, originates the concept of a "<u>socio-epistemo-technical system</u>" defining it as "a system that involves socially organised groups of people exploiting knowledge and technology in pursuance of goals".

[20] See Gell-Mann, [Gell-Mann 1994], for a discussion of this concept.

[21] According to Capra, [Capra 1996], the term "emergent properties" was coined by the philosopher C. D. Broad, [Broad 1923], to refer to those system properties that emerge at a certain level of complexity (or hierarchy) but do not exist at lower levels.

properties that are qualitatively different from the properties of its components[23][24]. For example, the unmistakable smell of gaseous ammonia is not present in the odourless nitrogen and hydrogen atoms that constitute its components.

Dependent on the nature of the components and system involved, emergent properties may or may not be predictable before the system is synthesised.[25] For example, consider a chemistry student who first experiences the smell of ammonia when it is synthesised as a gaseous by-product of a laboratory experiment that he is conducting - an unexpected and memorable event! In such circumstances, the observer, ie the student, did not predict the emergent properties of the ammonia system. However, it would be expected that the student would anticipate such emergent properties in subsequent experiments involving ammonia.

2.2.9 Systems Hierarchy

A system, created by integrating components into a complex whole, can be thought of as a multi-levelled structure of systems within systems. Each system in the structure is a whole with respect to its component parts and can also be a component of a system at a higher level in the structure. The various emergent properties of the composite system and its components characterise different levels of complexity in the composite system's structure.

A systems hierarchy is an architecture view[26] of a system from a structural perspective made on the basis of the existence of emergent properties.

Each level in a systems hierarchy is characterised by emergent properties that do not exist at other levels; higher levels in the systems hierarchy are not necessarily more complex than lower levels. It is emphasised that a systems hierarchy is not a hierarchy of the levels of complexity of a system; it is an architecture view of a system from the perspective of emergence not from the perspective of level of complexity.

It is also emphasised the systems hierarchy concept is not the same as the concept of the hierarchy of systems' complexity first proposed by Boulding, [Boulding 1956; Boulding 1956] and later professed by Checkland, [Checkland 1981]. Whereas a systems hierarchy discerns the different levels of emergence apparent in a single system, a hierarchy of

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[22] Others are communication and control. See Checkland, [Checkland 1981], for a discussion of these concepts.

[23] The expression "the whole is more than the sum of the parts" is often used in this context to describe the synergistic interaction of a system's components. Aristotle is usually attributed as being the first to have described this phenomenon, [Checkland 1981].

[24] Note that the emergent properties of a system do not necessarily result from the synergistic interaction of its components. Emergent properties can result from the "destructive" or "negative" interaction of a system's components; emergent properties can be "less than the sum of the parts". The term "antergy" has been proposed as a candidate label for this type of interaction and as an antonym for the noun "synergy", [Burke and Jarvis 1999].

[25] See Wartofsky, [Wartofsky 1968], for a discussion of these concepts.

[26] The concept of "architecture view" is defined in Section 2.2.11.

systems' complexity categorises commonly occurring systems into broad classes on the basis of their (highest) levels of complexity[27].

2.2.10 Architecture[28]

The Architecture of a system is the collective understanding[29] of a system of the community involved with that system.

The architecture of a system is often represented as a set of architecture descriptions.

2.2.11 Architecture Description

An Architecture Description is a representation of aspects of understanding about a system.

Given that appropriate system understanding is available, architecture descriptions can be produced for systems at all stages of their planning, design, implementation, maintenance and use.

2.2.11.1 Architecture View

Architecture Views are classes of architecture descriptions that allow understanding about systems to be represented from particular perspectives.

Appendix E provides a more detailed explanation of the concept of Architecture View. It also introduces the various special types of Architecture View including:

- Structural View;
- Piecewise View;
- Synoptic View;
- Panoptic View.

[27] Kline, [Kline 1995], proposes another hierarchy of systems' complexity based on the notion of a "complexity index" which he also defines and explains.

[28] The definitions of concepts relating to architecture are based on those from *Understanding Architecture*, [Burke 2000], which provides a fuller explanation of these concepts and gives various examples. It should be noted that the conception of architecture expressed in the April 2000 draft of *Understanding Architecture* is knowledge-based rather than thought-based. It defines the architecture of a system as "the collective knowledge about that system of the architecture community involved with that system"; it does not explicitly consider the feelings and wills of the community in regard of the system. It may be appropriate to revise this thinking in future versions.

[29] The concept of "understanding" is defined in Section 2.2.30.

2.2.12 Data[30]

Data is a set of symbols; it is a set of entities that could be, but have not been, used to represent meaning.

Data has no meaningful relation to anything else. It is free of context.

Examples of data include:

- sensations (ie sense stimuli) eg sounds, tastes, smells, touches, sights.
- characters eg numbers, letters, glyphs, @, +, ! , *, ~, |, etc
- binary quantities eg bits, etc
- analog quantities eg light pulses, energy states, wavelengths, shapes, movements, handwaves, etc

2.2.13 Data System

A Data System is an entity capable of symbol processing; it deals with data.

The purpose of a Data System is to process data. For example, the purposes of Data Systems often involve the generation, communication, reception, manipulation and storage of data. Organising is the generic term for symbol processing performed by Data Systems.

The input to a Data System is data; the output from a Data System is data. The output data of a Data System may result from some transformation that it performs on its input data.

Data Systems can be realised in animate, inanimate or hybrid forms; see below for examples.

Data Systems may involve the use of formalised schemes for representation and manipulation of symbols. There are many cases in which these activities are highly conducive to machine implementation through the appropriate application of technology. There are, however, many important cases in which they are not.

2.2.14 Order

Order is the faculty of organising; it is an emergent property of a Data System resulting from the interaction of its organising processes.

[30] Confusion is common regarding the meanings of the terms "data", "information", and "knowledge". Different authors use them in different ways. Accordingly, some readers may find it helpful to consider Appendix A of *Understanding Architecture, [Burke 2000]*, that presents ways in which the terms are used in contemporary discourse. It also discusses how a coherent understanding of the concepts they refer to can be developed and attempts to isolate distinguishing features of the concepts. This way of thinking has been used as the basis of the definitions and explanations presented here.

For a given observer and given inputs, the level of order of a Data System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between organising and order in a Data System: order enables organising processes; interacting organising processes create (higher level) order; (higher level) order enables (higher level) organising processes, etc.

Accordingly, the systems hierarchy of a Data System is characterised by the levels of order of the successive "unfoldings"[31] of this recursive relationship.

Figure 4 gives a synoptic view of a Data System.

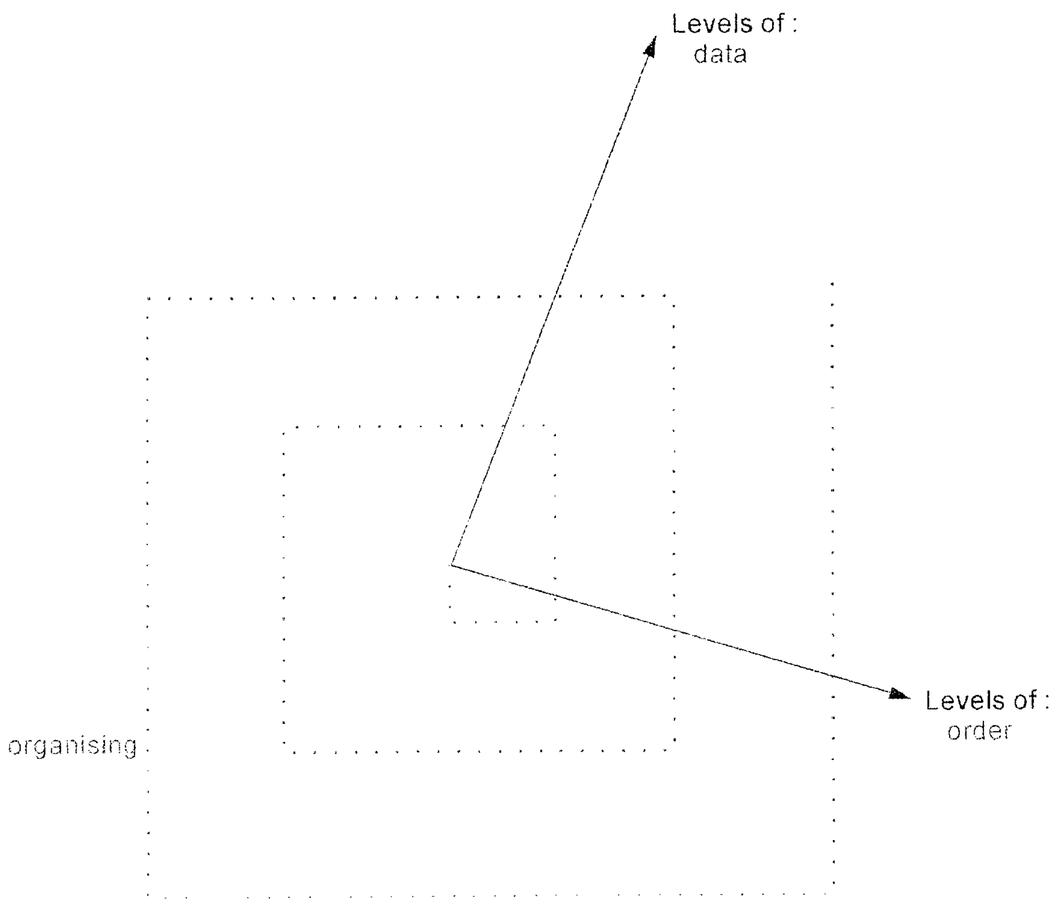

Figure 4: Data Systems: a Synoptic View

[31] Note that according to Gell-Mann, [Gell-Mann 1994], the words "simplicity" and "complexity" have common etymological roots. "Simplicity" is derived from an expression meaning "once folded"; "complexity" from an expression meaning "braided together". Hence it is suggested that the use of the term "unfoldings" in the context of recursive relationships is appropriate from both a linguistic and metaphoric point of view.

2.2.15 Information

Information is a set of signs; it is a set of entities used to represent meaning.

It entails a relationship between symbols and what they represent. Information is data in context; it is a set of signs as opposed to a set of symbols. The complexity of information depends upon the intricacy of this context.

Examples of information include:
- perceptions;
- measurements;
- facts;
- equations;
- icons;
- musical scores;
- diagrams;
- maps;
- timetables;
- telephone directories.

2.2.16 Information System

An Information System is an entity capable of sign processing; it deals with data and information.

The purpose of an Information System is to process information. For example, the purposes of Information Systems often involve the generation, communication, reception, interpretation, manipulation and storage of information. Computing is the generic term for sign processing performed by Information Systems.

The input to an Information System may be information and/or data; the output from an Information System is information. The output of an Information System may result from some transformation that it performs on its input.

Correct processing of information requires preservation of the relationships between the signs being processed and what they represent. An incorrectly functioning Information System can distort the meaning of the information that it processes. Information Systems can assign meaning to data and information; they cannot, in their own right, derive meaning from information.

For example, consider the case of a plotting program - a simple Information System - that takes as input a list of number pairs signifying the heights and weights of a group of children and generates a representation of that list by treating the number pairs as coordinates on a two-dimensional framework. The resultant "scatter diagram"[32], is much more accessible to a human observer than the list of number pairs and may enable a relationship between the children's heights and weights to be discerned by the observer. For instance, the observer may notice a trend that suggests that the height and weight are positively correlated, ie tall children tend to be heavier than short children. The meaning that can be derived from the program's output by the observer is clearly strongly influenced by the program. The program, however, has not appreciated the meaning of the input, the output or of any processing that it has performed; it has merely followed instructions made by its programmer in a mechanistic manner. Furthermore, if the program contains errors it can change the meaning that the observer derives from its output. For instance, if the program was to mistakenly transpose the number pairs without altering the labelling of the axes of the plot then the observer will be misinformed and may make erroneous conclusions regarding the trends that exist between the heights and weights of the children.

Information Systems can be realised in animate, inanimate or hybrid forms.

Examples of animate Information Systems include:

- pheromone signs;
- "body language", eg hand signals, facial expressions, posturing, dancing, etc.
- "counting on your fingers";
- "sign language" for the hearing impaired;
- spoken language.

Examples of inanimate Information Systems include:

- tokens, eg shell counters, money, etc;
- abacuses;
- photocopiers;
- tape recorders;
- telephones;
- fax machines;
- calculators;
- written language;
- computer programs;
- Internet;
- World Wide Web.

Examples of hybrid Information Systems include:

- flag waving;
- using semaphore;
- performing with hand puppets;
- playing musical instruments.

Note that each of the examples of Information Systems listed above becomes an example of a Data System if meaning is disassociated from the signs and/or sign processing involved.

[32] See Chatfield , [Chatfield 1983], for a discussion of this concept.

For example, two fax machines act as an Information System if they are used to transmit a replica of a message written in English text from one to the other. The same two machines act as a Data System if they are used to transmit a replica of a collection of symbols to which no meaning has been assigned.

Information Systems may involve the use of formalised schemes for representation and manipulation of signs, eg writing, iconographic schemes used in "signage", fine art etc. There are many cases in which (aspects of) these activities are highly conducive to machine implementation through the appropriate application of technology, eg word-processing, spelling checking, grammar checking, theorem proving, etc. There are, however, many important cases in which they are not, eg report writing, poetry writing, etc.

2.2.17 Intelligence

Intelligence is the faculty of computing; it is an emergent property of an Information System resulting from the interaction of its computing processes.

For a given observer and given inputs, the level of intelligence of an Information System is the complexity of the relationships between the system's inputs and outputs.

For example, consider the spelling checking program, the grammar checking program and the "copy " function provided as part of a standard word-processor package such as Microsoft Word. The level of intelligence of the grammar checking program appears to be relatively high compared with that of the spelling checking program since the relationships between the inputs and outputs of the grammar program seem to be much more complex than those of the spelling program. The level of intelligence of the spelling checking program appears, however, to be significantly greater than that of the "copy" function. Minimal levels of intelligence are exhibited by Information Systems that merely replicate information such as "copy" functions, photocopiers, faxes, etc.

There is an inherently recursive relationship between computing and intelligence in an Information System: intelligence enables computing processes; interacting computing processes create (higher level) intelligence; (higher level) intelligence enables (higher level) computing processes, etc.

Accordingly, the systems hierarchy of an Information System is characterised by the levels of intelligence of the successive "unfoldings" of this recursive relationship.

Figure 5 gives a synoptic view of an Information System.

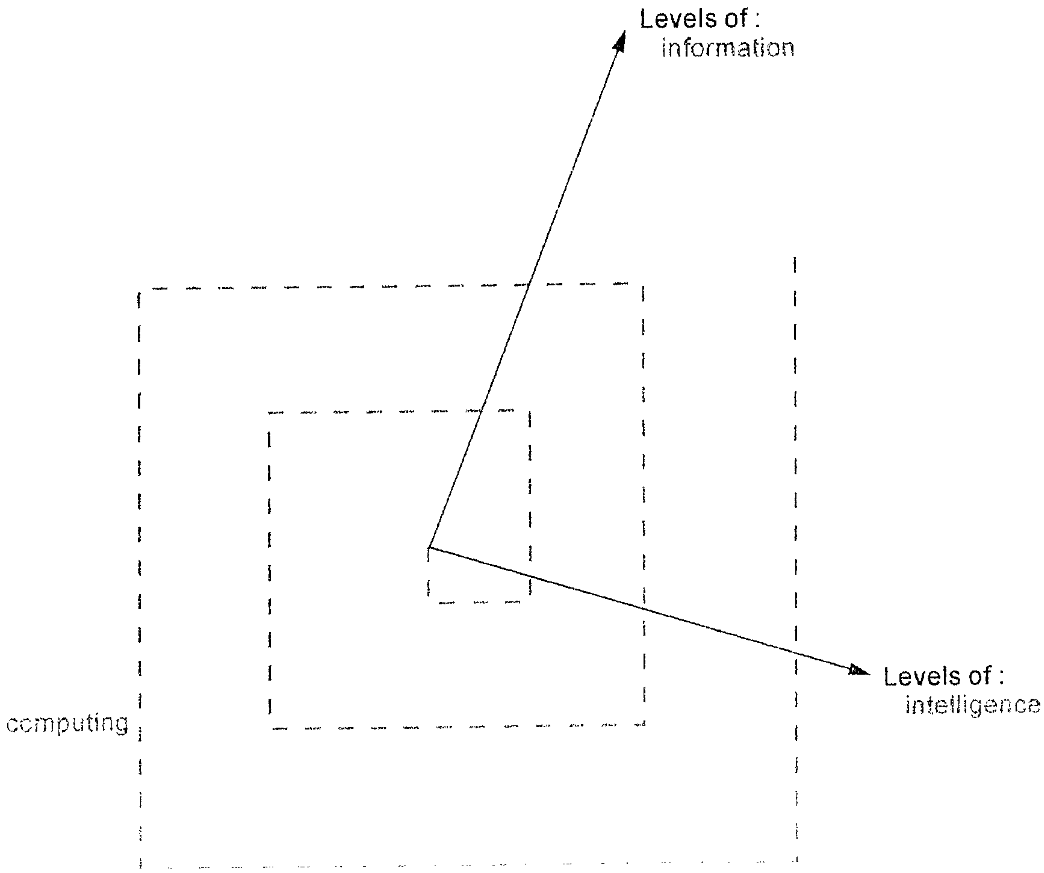

Figure 5 *Information Systems: a Synoptic View*

2.2.18 Knowledge

Knowledge is meaning derived from information and other knowledge.

Knowing is the process by which meaning is derived from information and other knowledge[33]. Knowing occurs by processing schemata relating to cultural, theoretical and practical matters[34].

Knowing schemata may be learned or inherent.

[33] It is emphasised that knowing is not necessarily a rational process. It is not synonymous with reasoning; neither is it restricted to propositions to which truth-values can be assigned. See Edgar and Sedgwick, [Edgar and Sedgwick 1999], for a brief summary of the academic discourse concerning the nature of rationality. Also see Descartes, [Descartes 1986 (1637 and 1641)], Hume, [Hume 1990 (1739)], Kant, [Kant 1964 (1781)], Nietzsche, [Neitzsche 1986 (1878 - 80)], etc.

[34] Note the parallels between this conception of knowing and that of socio-epistemo-technical systems.

Knowing is distinguished from both feeling and willing, which are processes associated with feelings and will respectively.

Table 2 gives some examples of specific processes of knowing.

perceiving	conceiving	reasoning	learning
representing	experimenting	analysing	synthesising
creating	guessing	speculating	intuiting
assimilating	integrating	fusing	combining
associating	disassociating	matching	recognising
observing	measuring	interpreting	construing
appreciating	considering	appraising	judging
criticising	idealising	researching	exploring
investigating	believing	approximating	visualising
imagining	conceptualising	theorising	modelling
categorising	generalising	abstracting	comprehending
proving	disproving	explaining	deciding
innovating	devising	designing	describing
expressing	depicting	anticipating	predicting
organising	structuring	regulating	planning
improvising	adapting	compensating	confusing

Table 2 Examples of processes of knowing

Appendix D summarises the views of some prominent Occidental thinkers regarding the nature of knowledge.

Note that the definition of knowledge provided above contrasts starkly with the understanding of the nature of (individual) knowledge that underpins most, but not all[35], conventional Occidental thinking; it accords more closely with the understandings of some Oriental traditions[36]. It takes meaning to be the essence of knowledge; neither the "truth" of knowledge nor the means by which knowledge is assured, justified or verified are considered to be of primary significance[37][38]. This semantic and subjective[39] conception

[35] See, for example, [Lakoff and Johnson 1980], [Jordan 1993], [Wenger 1990], [Wenger 1998].
[36] See, for example, Yu-Lan, [Yu-Lan 1948], for a discussion of Chinese philosophy.
[37] See Edgar and Sedgwick, [Edgar and Sedgwick 1999], for a brief summary of the academic discourse concerning the nature of rationality.
[38] Appendix J discusses how, even in the domain of science, the "truth" of knowledge is not necessarily a primary concern.
[39] Appendix A discusses the objectivity and subjectivity of knowledge.

supports a consistent understanding of the cognition and consciousness that emerges from both individuals and groups - a central concern of this work[40].

For example, consider a scenario in which five people with different backgrounds and ways of thinking are asked to consider to the same simple system, namely a diamond.[41] Let the people be a scientist, a jeweller, an engineer, a capitalist and a poet. In such circumstances, if the people were unable to confer, it would be expected that the individuals' knowledge of the system would differ significantly. Figure 6 depicts how this might be the case. The individuals derive different meaning from the same information; neither the veracity of their deliberations nor how they were conducted is of primary relevance.

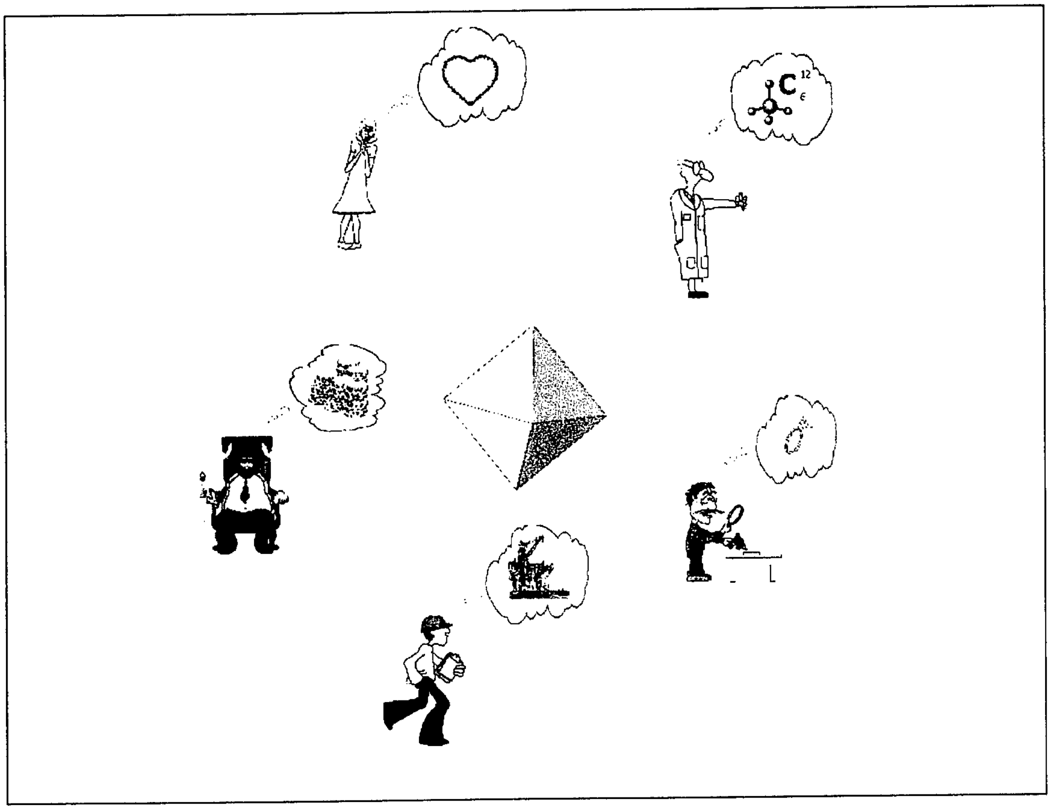

Figure 6 *Derivation of meaning by a diverse group.*

Burke, [Burke 2000], discusses this example at some length using it to illustrate the role of representation in the development of both individual and group knowledge.

[40] It also lends itself to consideration of the knowledge structures in TWAW in which the allies and adversaries have from different thinking traditions – a vital issue in the Australian context.
[41] In Checkland's , [Checkland 1981], hierarchy of systems complexity, a diamond belongs to the lowest of nine levels of increasingly high complexity. Note that this hierarchy is based on that proposed originally by Boulding, [Boulding 1956].

2.2.19 Knowledge System

A Knowledge System is an entity capable of knowing; it deals with data, information and knowledge.

Knowledge exists only in Knowledge Systems; it is what a Knowledge System knows.

Knowledge results from the activity of a Knowledge System in deriving meaning from information and other knowledge. The quality of knowledge depends upon both the capacity of the Knowledge System to derive meaning and the data, information and knowledge accessible to the entity. The human mind currently has a capacity for knowing that vastly exceeds that of any other Knowledge System that exists or can realistically be anticipated[42]. Consequently, the vast majority of high quality knowledge in existence resides in the minds of human beings, and this can be expected to remain the case.

Unlike data and information, knowledge cannot be communicated directly by current systems. Attempts to communicate knowledge require the originator of the knowledge to represent it in a way that can be communicated directly. Knowledge Systems, ie entities capable of knowing, that subsequently access such representations of knowledge, including their originators, need to derive meaning from it in order to acquire knowledge. Knowledge derived in this way depends upon both the capacity of the Knowledge System to derive meaning and the information and knowledge that it already has. No two such derivations, at least by animate Knowledge Systems, can be absolutely identical. High levels of consensus can be achieved, however, through the imposition of various constraints on the processes described above.

Various types of Knowledge Systems are possible.

2.2.19.1 Natural Knowledge Systems

A Natural Knowledge System is a Knowledge System that has been synthesised by some natural process or processes. Individual animate beings constitute the vast majority of natural Knowledge Systems currently in existence. Furthermore, some collectives of animate beings, eg ant colonies, can be considered to be capable of knowing in some ways and are therefore also considered to constitute Natural Knowledge Systems.

2.2.19.2 Non-Natural Knowledge Systems

A Non-Natural Knowledge System is a Knowledge System that has been synthesised by some non-natural process or processes. Some computer programs can be considered to be capable of knowing in a limited sense and therefore constitute primitive Non-Natural Knowledge Systems. The realisation of more sophisticated Non-Natural Knowledge Systems is anticipated to be through developments in Artificial Intelligence, Intelligent Agents, etc.

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[42] Kurweil constructs an argument to the contrary in *The Age of Spiritual Machines*, [Kurzweil 1999].

2.2.19.3 Hybrid Knowledge Systems

A Hybrid Knowledge System is a Knowledge System that has been synthesised by a combination of natural and non-natural processes. The author is not currently aware of any existing Hybrid Knowledge Systems[43]; the realisation of Hybrid Knowledge Systems is anticipated to be through developments in bio-engineering, genetic engineering etc. and Artificial Intelligence, Intelligent Agents, etc. [44]

2.2.19.4 Artificial Knowledge Systems

An Artificial Knowledge System is either a Non-Natural Knowledge System or a Hybrid Knowledge System.

2.2.20 Cognition

Cognition is the faculty of knowing; it is an emergent property of a Knowledge System resulting from the interaction of its knowing processes.

For a given observer and given inputs, the level of cognition of a Knowledge System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between knowing and cognition in a Knowledge System: cognition enables knowing processes; interacting knowing processes create (higher level) cognition; (higher level) cognition enables (higher level) knowing processes, etc.

Accordingly, the systems hierarchy of a Knowledge System is characterised by the levels of cognition of the successive "unfoldings" of this recursive relationship.

Cognition is distinguished from both emotion and volition, which are considered as emergent properties of Feeling Systems and Will Systems respectively.

Perception, conception and reasoning are important classes of cognition.

Figure 7 gives a synoptic view of a Knowledge System.

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[43] MAJGEN Sidney Shachnow, [Shachnow 1992], of the US Special Operations Command has presented a "technology time line" projected to the year 2020 that includes the idea of "synthetic telepathy". It is presumed that, if realised, synthetic telepathy would be enabled through some form of Hybrid Knowledge System.

[44] See Kurzweil, [Kurzweil 1999], for a discussion of these possibilities.

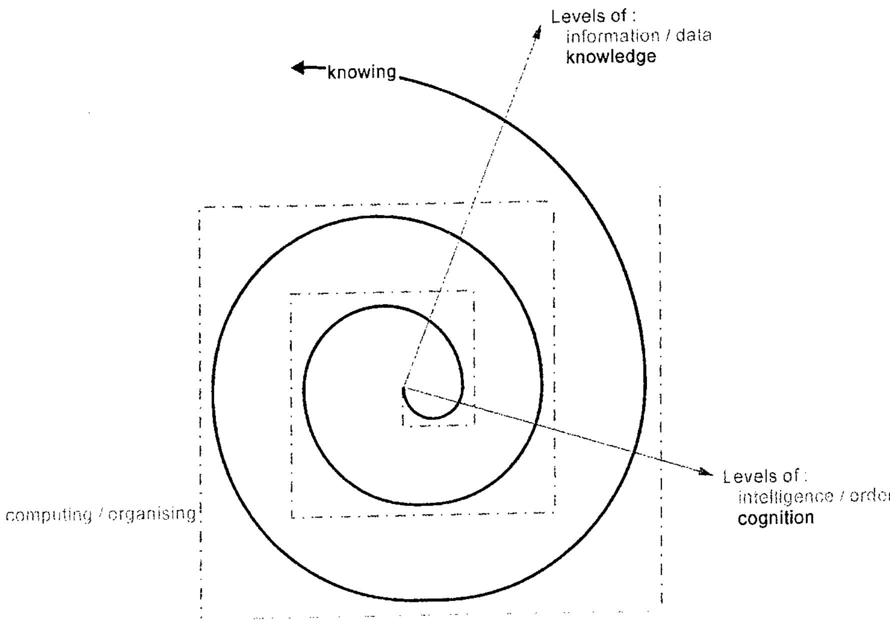

Figure 7 *Knowledge Systems: a Synoptic View*[45][46]

2.2.21 Feelings

Feelings are meaning derived from information and other feelings.

Feeling is the process by which meaning is derived from information and other feelings. Feeling occurs by processing schemata relating to instinctive sensibilities.

Feeling schemata may be learned or inherent.

Feeling is distinguished from both knowing and willing, which are processes associated with knowledge and will respectively.

Table 3 gives some specific examples of feelings.

[45] In Figure 7 the synoptic views of Data Systems and Information Systems given in Figures 5 and 6 respectively are overlaid to provide a combined Data/Information Systems synoptic view; this is represented by the chain dotted "squared spiral". This approach is used in the all other synoptic views provided in Section 2.

[46] The combined Data/Information Systems synoptic view can be regarded as a representation of what has been referred to as the "information backplane" or "infostructure", [Alberts, Garstka et al. 1999].

joy	fear	loneliness	meaninglessness
love	hate	envy	ecstasy
anger	lust	panic	worry
righteousness	invasion	injustice	agitation
disappointment	let down	harassment	outrage
abhorrence	dismay	boredom	satisfaction
appreciation	rejection	fulfilment	being ignored
being criticised	irritation	helplessness	optimism
pessimism	belonging	identity	peacefulness
calm	anguish	grief	unfairness
abandon	abandonment	being praised	rushed
"rush"	rejection	being soothed	being blessed
relief	justification	giving forgiveness	being forgiven
damned	doubt	expectation	anticipation
release	contentment	superiority	inferiority
relaxation	distress	being unloved	safety
being used	pity	despair	

Table 3 Examples of feelings

2.2.22 Feeling System

A Feeling System is an entity capable of feeling; it deals with data, information and feelings.

Feelings exist only in Feeling Systems; it is what a Feeling System feels.

Feelings result from the activity of a Feeling System in deriving meaning from information and other feelings. The quality of feelings depends upon both the capacity of the Feeling System to derive meaning and the data, information and feelings accessible to the entity.

Feelings do not currently occur in inanimate entities.

Unlike data and information, feelings cannot be communicated directly by current systems. Attempts to communicate feelings require the originator of the feelings to represent them in a way that can be communicated directly. Feeling Systems, ie entities capable of feeling, that subsequently access such representations of feelings, including their originators, need to derive meaning from it in order to acquire feelings. Feelings derived in this way depend upon both the capacity of the Feeling System to derive meaning and the information and feelings that it already has. No two such derivations, at least by existing animate Feeling Systems, can be absolutely identical. High levels of consensus can be achieved, however, through the imposition of various constraints on the processes described above.

Various types of Feeling Systems are conceivable but not necessarily possible.

2.2.22.1 Natural Feeling Systems

A Natural Feeling System is a Feeling System that has been synthesised by some natural process or processes. Individual animate beings constitute the vast majority of natural Feeling Systems currently in existence. Furthermore, some collectives of animate beings, eg ant colonies, can be considered to be capable of feeling in some ways and are therefore also considered to constitute Natural Feeling Systems.

2.2.22.2 Non-Natural Feeling Systems

A Non-Natural Feeling System is a Feeling System that has been synthesised by some non-natural process or processes. Non-Natural Feeling Systems do not exist currently; the author is not aware of any non-natural entity, eg a computer program or device, which can be considered to be capable of feeling, even in a limited sense. In the future, developments in Artificial Intelligence, Intelligent Agents, etc, may make it possible to realise some form of primitive Non-Natural Feeling Systems.

2.2.22.3 Hybrid Feeling Systems

A Hybrid Feeling System is a Feeling System that has been synthesised by a combination of natural and non-natural processes. The author is not currently aware of any existing Hybrid Feeling Systems; the realisation of Hybrid Feeling Systems may become possible through developments in bio-engineering, genetic engineering etc. <u>and</u> Artificial Intelligence, Intelligent Agents, etc. [47]

2.2.22.4 Artificial Feeling Systems

An Artificial Feeling System is either a Non-Natural Feeling System or a Hybrid Feeling System.

2.2.23 Emotion

Emotion is the faculty of feeling; it is an emergent property of a Feeling System resulting from the interaction of its feeling processes.

For a given observer and given inputs, the level of emotion of a Feeling System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between feeling and emotion in a Feeling System: emotion enables feeling processes; interacting feeling processes create (higher level) emotion; (higher level) emotion enables (higher level) feeling processes, etc.

Accordingly, the systems hierarchy of a Feeling System is characterised by the levels of emotion of the successive "unfoldings" of this recursive relationship.

Figure 8 gives a synoptic view of a Feeling System.

[47] See Kurzweil, [Kurzweil 1999], for a discussion of these possibilities.

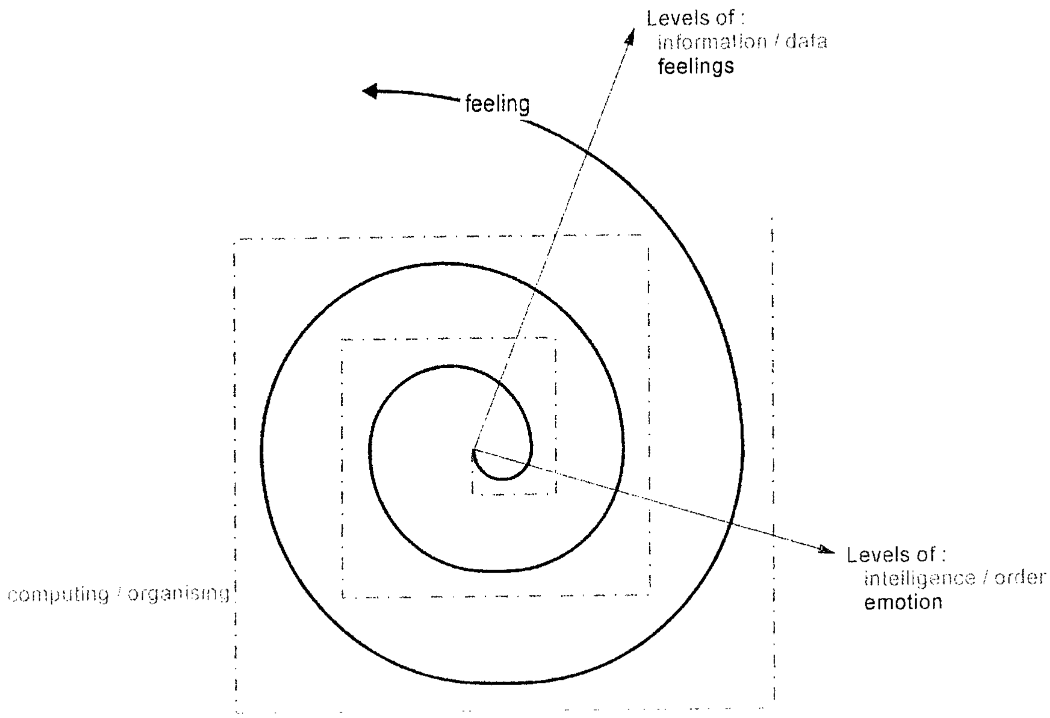

Figure 8 *Feeling Systems: a Synoptic View*

Individual animate entities, in particular individual human beings, are currently capable of producing the most subtle, sensitive and sophisticated feelings. Large groups of animate beings currently produce the most powerful emotions. Notable examples of emotions that emerge from large groups include:

- the strong (mixed) emotions experienced by rock concert audiences[48], religious gatherings[49], crowds of sports spectators[50], etc;
- the mass hysteria/panic that occurs in stampeding herds, crowds of people evacuating burning premises, etc;

[48] Notable examples of this include the Band Aid and Live Aid (broadcasted) concerts that orchestrated emotional responses from their local and remote audiences in order to raise money to relieve famine in Ethiopia. Similarly, the Christmas concert staged for the Interfet troops in East Timor in 1999 played an important role in boosting the morale of both the troops and the Australian public at large.

[49] For example, the funeral of Diana, Princess of Wales was religious event, but also a significant event in modern global culture, that evoked a deep emotional response from the crowds of people who attended the funeral in person and also the millions worldwide who watched the television broadcast of the proceedings.

[50] A global television audience estimated as 2 - 4 billion people, ie 33% - 66% of the world's population, watched the 1998 World Cup Final between France and Brazil; as such it was the largest shared experience in the history of humanity. With the emotional benefit of playing in their national stadium in front of a partisan crowd, the French unexpectedly defeated the Brazilian favourites 3 – 0. The match produced an emotional response that was literally felt around the world.

- the collective emotion displayed by one group of humans towards others. This can be manifest in various ways including racial hatred[51], xenophobia, etc;
- the public outrage displayed by the population at large on learning of the perpetration of atrocities[52], crimes against humanity[53], etc;
- "feeding frenzy".

2.2.24 Will

Will is meaning derived from information and other will.

Willing is the process by which meaning is derived from information and other will. Willing occurs by processing schemata relating to the determination to effect specific activities or outcomes.

Willing schemata may be learned or inherent.

Willing is distinguished from both knowing and feeling, which are processes associated with knowledge and feelings respectively.

Table 4 gives some specific examples of will.

[51] A notable example of this phenomenon is that of the Nazi's collective hatred and subsequent persecution of the Jews.

[52] For example, there was a profound emotional response by the Australian people to the Port Arthur massacre. This was a major contributing factor in the subsequent reform of the Australian gun laws and to changes in the national attitude towards gun ownership.

[53] For example, on first becoming aware of the existence of the Nazi extermination camps, there was a profound emotional response around the world. This was a significant factor in subsequent global politics and in particular had a bearing on the creation of the state of Israel.

to live	to reproduce	to win	to succeed
to own	to belong	to have power	to be responsible
to be respected	to contribute	to influence	to change
to glorify God	to go to Heaven	To achieve Enlightenment	to reduce suffering
to be virtuous	to be famous	to be appreciated	to be remembered
to protect	to defend	to pacify	to appease
to pursue justice	to further a cause	to avenge	to recover
to kill	to maim	to mutilate	to destroy
to persecute	to deny	to defy	to desecrate
to deceive	to rectify	to discover	to research
to understand	to learn	to create	to express
to build	to grow	to be free	to escape
to take risks	to avoid risks	to be autonomous	to be secure
to be beautiful	to be healthy	to be happy	to communicate
to be loved	to have an easy life	to cause no harm	to cure
to nurture			

Table 4 Examples of will

2.2.25 Will System

A Will System is an entity capable of willing; it deals with data, information and will.

Will exists only in Will Systems; it is what a Will System wills.

Will results from the activity of a Will System in deriving meaning from information and other will. The quality of will depends upon both the capacity of the Will System to derive meaning and the data, information and will accessible to the entity.

Will does not currently occur in inanimate entities.

Unlike data and information, will cannot be communicated directly by current systems. Attempts to communicate will require the originator of the will to represent it in a way that can be communicated directly. Will Systems, ie entities capable of willing, that subsequently access such representations of will, including their originators, need to derive meaning from it in order to acquire will. Will derived in this way depends upon both the capacity of the Will System to derive meaning and the information and will that it already has. No two such derivations, at least by existing animate Will Systems, can be absolutely identical. High levels of consensus can be achieved, however, through the imposition of various constraints on the processes described above.

Various types of Will Systems are conceivable but not necessarily possible.

2.2.25.1 Natural Will Systems

A Natural Will System is a Will System that has been synthesised by some natural process or processes. Individual animate beings constitute the vast majority of natural Will Systems currently in existence. Furthermore, some collectives of animate beings, eg ant colonies, can be considered to be capable of will in some ways and are therefore also considered to constitute Natural Will Systems.

2.2.25.2 Non-Natural Will Systems

A Non-Natural Will System is a Will System that has been synthesised by some non-natural process or processes. Non-Natural Will Systems do not exist currently; the author is not aware of any non-natural entity, eg a computer program or device, which can be considered to be capable of will, even in a limited sense. In the future, developments in Artificial Intelligence, Intelligent Agents, etc, may make it possible to realise some form of primitive Non-Natural Will Systems.

2.2.25.3 Hybrid Will Systems

A Hybrid Will System is a Will System that has been synthesised by a combination of natural and non-natural processes. The author is not currently aware of any existing Hybrid Will Systems; the realisation of Hybrid Feeling Systems may become possible through developments in bio-engineering, genetic engineering etc. and Artificial Intelligence, Intelligent Agents, etc. [54]

2.2.25.4 Artificial Will Systems

An Artificial Will System is either a Non-Natural Will System or a Hybrid Will System.

2.2.26 Volition

Volition is the faculty of willing; it is an emergent property of a Will System resulting from the interaction of its willing processes.

For a given observer and given inputs, the level of volition of a Will System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between willing and volition in a Will System: volition enables willing processes; interacting willing processes create (higher level) volition; (higher level) volition enables (higher level) willing processes, etc.

Accordingly, the systems hierarchy of a Will System is characterised by the levels of volition of the successive "unfoldings" of this recursive relationship.

Figure 9 gives a synoptic view of a Will System.

[54] See Kurzweil, [Kurzweil 1999], for a discussion of these possibilities.

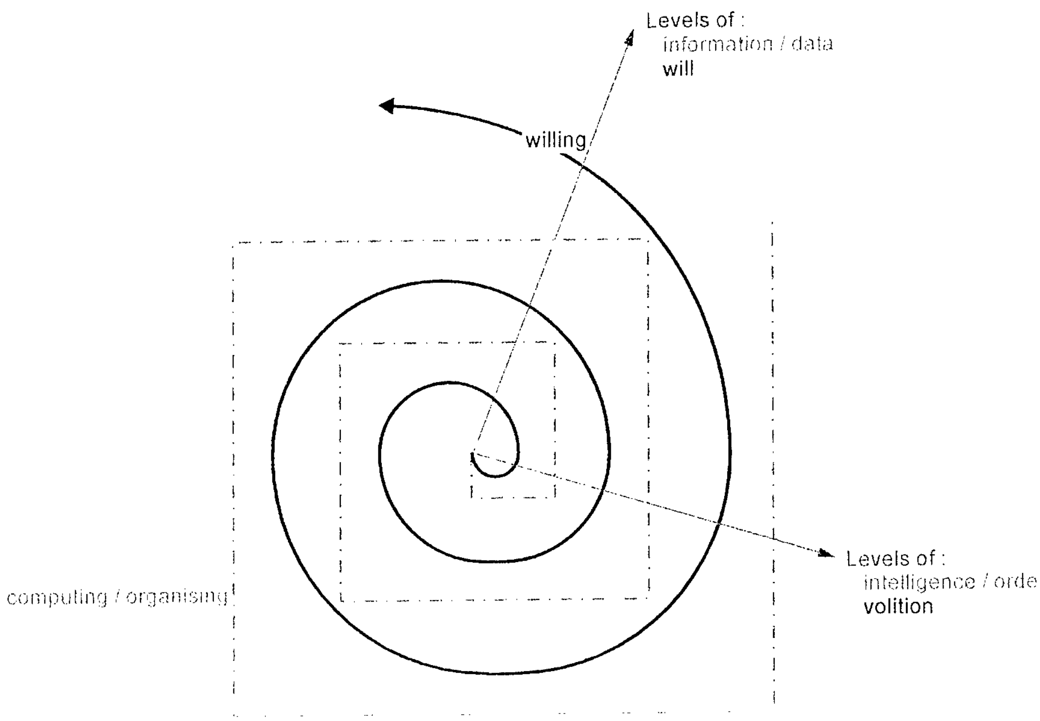

Figure 9 *Will Systems: a Synoptic View*

Individual animate entities are currently capable of producing the most directed and specific will. Large groups of animate beings currently produce the most powerful volition. Notable examples of volition that emerge from large groups include:

- the collective will of groups of animals to migrate *en masse*[55];
- the collective will of one group of human beings to destroy or disadvantage others. This can be manifested in various ways including genocide, "racial cleansing", discrimination, "lynch mobs", "blood lust", etc;
- the collective will of groups of people to pursue causes. This can be manifested in various ways including crusades[56], jihads, pilgrimages, etc.;
- the collective will of groups to self-destroy, eg "suicide cults", etc.

[55] The strength of such volition overwhelms even basic individual instincts such as the will to survive. In the case of lemmings, which are small arctic rodents, huge numbers can die from drowning as their collective migratory instinct compels them to throw themselves over cliff-edges and into the sea.

[56] The original Crusades were expeditions of Western European Christians to recover Jerusalem from the Muslims. Expeditionary forces "spontaneously" formed as a result of a papal decree that all who died in pursuit of the cause would achieve salvation.

2.2.27 Thought

Thought is meaning derived from knowledge, will, feelings and other thoughts; it is a state of mind[57].

Thinking is the process by which meaning is derived from knowledge, will, feelings and other thoughts.

Thoughts are outputs of Thought Systems; they result from the interaction of a Thought System's Knowledge System, Will System and Feeling System components.

Wills, feelings and knowledge are classes of thoughts resulting from the independent action of a Thought System's Knowledge System, Will System and Feeling System components respectively.

Values and beliefs are classes of thoughts. Values and beliefs can strongly influence subsequent thoughts[58].

Decisions are a class of thoughts usually resulting from the dependent interaction of a Thought System's Knowledge System, Will System and Feeling System components.

Intentions are decisions to act. Therefore, intentions are a class of thoughts.

2.2.28 Thought System

A Thought System is an entity capable of thinking; it deals with data, information, knowledge, will and feelings.

Thought exists only in Thought Systems; it is what a Thought System thinks.

A Thought System has at least one component that is either a Knowledge System or Feeling System or Will System; it may also have components that are Information Systems and/or Data Systems.

A composite Thought System has more than one component. In the extreme and atypical case, a Thought System can comprise just an isolated Knowledge System, Feeling System or Will System.

Examples of Thought Systems include:
- individual human minds;
- insect colonies;
- the Knowledge Systems Building, DSTO, Salisbury;
- Headquarters Australian Theatre (HQAST);

[57] In this work, the term "mind" is used in the following sense: "Mind is the seat of cognition, emotion, volition and consciousness, it is that which knows, feels, wills and thinks."
[58] See Boulding, [Boulding 1956], for a discussion of this relationship.

- Australian Defence Headquarters (ADHQ).

Various other examples of existing and conjectured Thought Systems are discussed in later Sections of the paper.

2.2.29 Consciousness

Consciousness is the faculty of thinking; it is an emergent property of a Thought System resulting from the interaction of its thinking processes.

For a given observer and given inputs, the level of consciousness of a Thought System is the complexity of the relationships between the system's inputs and outputs.

There is an inherently recursive relationship between thinking and consciousness in a Thought System: consciousness enables thinking processes; interacting thinking processes create (higher level) consciousness; (higher level) consciousness enables (higher level) thinking processes, etc.

Accordingly, the systems hierarchy of a Thought System is characterised by the levels of consciousness of the successive "unfoldings" of this recursive relationship.

Figures 1 and 10 give synoptic views of a Thought System.

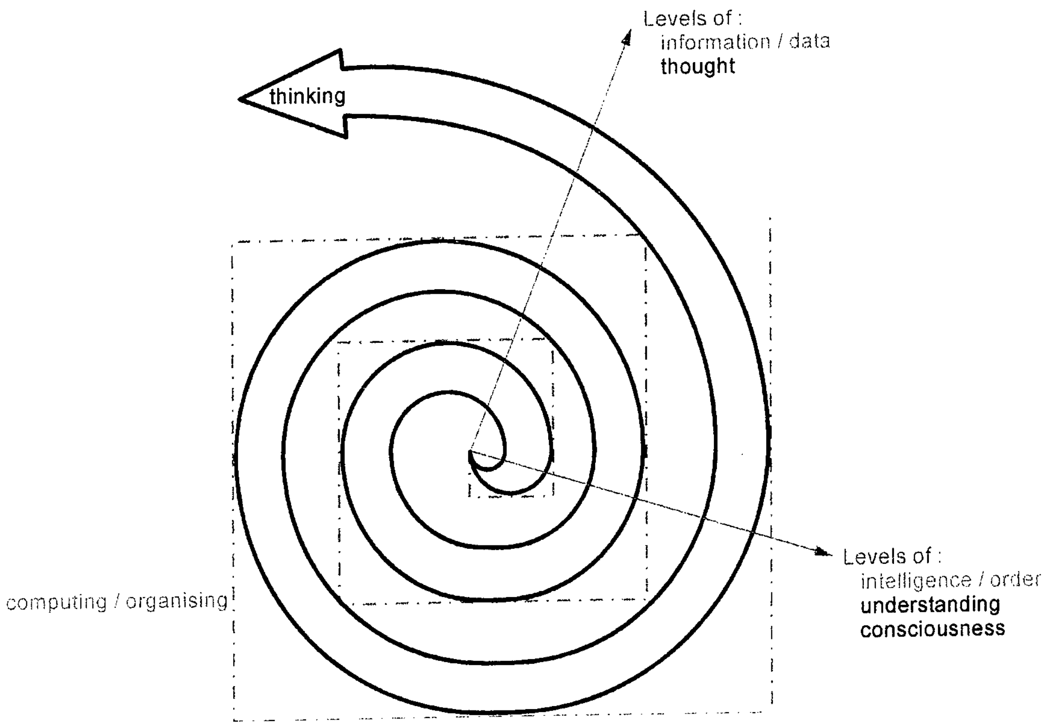

Figure 10 *Thought Systems: a Synoptic View*

Cognition, volition and emotion are all modes of consciousness; they can occur independently or in interaction. The independent modes are special cases and do not occur frequently in naturally synthesised Thought Systems.

As well as being an emergent property of a Knowledge System, cognition can also be an emergent property of a Thought System. The type of cognition that emerges from a composite Thought System is typically different to that of its Knowledge System component(s).

As well as being an emergent property of a Feeling System, emotion can also be an emergent property of a Thought System. The type of emotion that emerges from a composite Thought System is typically different to that of its Feeling System component(s).

As well as being an emergent property of a Will System, volition can also be an emergent property of a Thought System. The type of volition that emerges from a composite Thought System is typically different to that of its Will System component(s).

For a given observer and given inputs, the level of understanding of a Thought System is the complexity of the system's outputs.

Accordingly, each level in the systems hierarchy of a Thought System is characterised by a level of understanding as well as a level of consciousness.

2.2.31 Culture

A culture is the (system of) processes and practices by which a group of Thought Systems attempts to share thoughts, ie to share meaning.

Key issues in culture[59] are:
- representation;
- regulation;
- production;
- consumption;
- identity/sense of belonging.

Thought Systems that share the same culture use information to express themselves in ways that are likely to be understood consistently by each other and interpret information in roughly the same ways. Culture influences the behaviour of individual Thought Systems; it can also organise and regulate the dependent and inter-dependent behaviour of the members of a group of Thought Systems.

2.2.32 Culture System

A Culture System is a System of Thought Systems[60] that attempts to share thoughts, ie to share meaning, by operating within one or more shared cultures.

Note that a Culture System is itself a Thought System; as a System of Thought Systems, ie a system whose components are Thought Systems, a Culture System is necessarily a Thought System.

Figure 11 is a synoptic view of a Culture System comprising two similar Thought Systems operating within similar but different cultures. This may be representative, for example, of two single services operating jointly or two national Defence forces operating in coalition. Considerable interaction occurs between the Thinking Systems' processes which gives rise to various emergent properties including:
- collective consciousness;
- collective understanding;
- shared consciousness;

[59] See Hall, [Hall 1997], du Gay, [Gay 1997], Thompson, [Thompson 1997], Barrett, [Barrett 1991] and Edgar and Sedgwick, [Edgar and Sedgwick 1999] for a discussion of these issues.
[60] Appendix I provides brief definitions and explanations of the main concepts relating to Systems of Systems.

Considerable interaction occurs between the Thinking Systems' processes which gives rise to various emergent properties including:

- collective consciousness;
- collective understanding;
- shared consciousness;
- shared understanding[61].

The Figure suggests that, in the specific case that it depicts, some commonality exists between the Thought System components and that the Culture System is reasonably coherent. Although there are circumstances in which this would be an acceptable situation in TWAW, it is a situation that ideally should be improved.

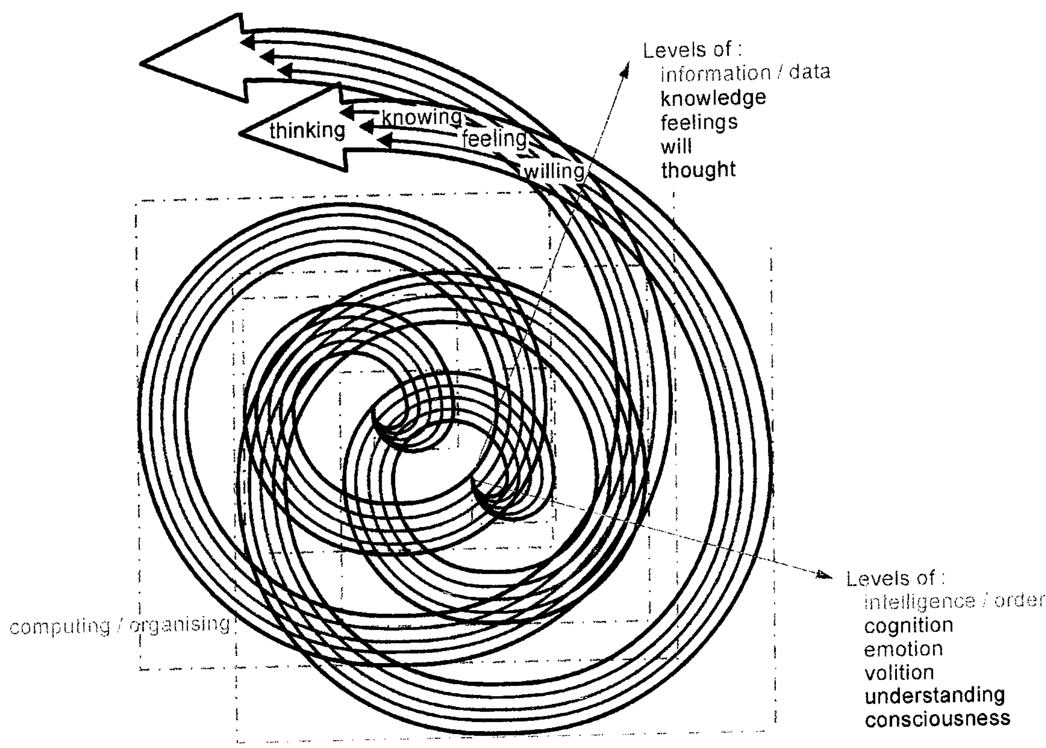

Figure 11 Culture Systems: A Synoptic View of a Culture System with two similar Thought Systems components operating within similar cultures.

Figures 12 is a synoptic view of a Culture System comprising two different Thought Systems - one dominates the other - operating within different cultures. This may be representative, for example, of two potentially adversarial Defence forces interacting to

[61] See *Understanding Architecture*, Section 4, [Burke 2000], for a discussion of the distinction between the terms "collective", "shared" and "common".

avoid conflict and maintain peace. Considerable interaction between the Thinking Systems' processes which gives rise to various emergent properties including:

- collective consciousness;
- collective understanding;
- shared consciousness;
- shared understanding.

The Figure suggests that, in the specific case that it depicts, that despite the lack of commonality between the Thought System components, considerable coherence is achieved in the Culture System. There are circumstances in which this would be a highly desirable situation in TWAW, particularly in Thought Anti-War.

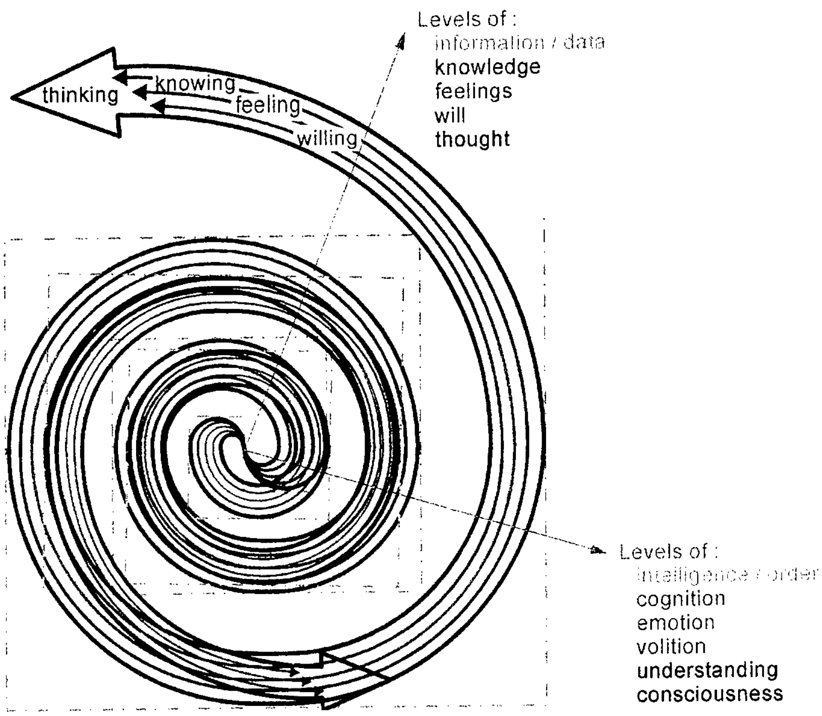

Figure 12 Culture Systems: A Synoptic View of a Culture System with two dissimilar Thought Systems components operating within dissimilar cultures.

2.3 Discussion

This Section is a conceptualisation[62] of the domain of Thought Systems. As such, it represents the core of a conceptualisation of the domain of Thought Warfare and Anti-Warfare that is the primary focus of this work. It has been produced as a result of an exercise in Architecture Thinking[63] in which architecture is considered to be what a community understands about a system.

There is an inherent plurality in this domain of thought[64]. It follows, therefore, that no monistic conception will be able to accommodate all of its aspects. Different conceptions can, however, be useful for different specific purposes. The thinking presented in this Section has been developed for a specific purpose: to afford a readily grasped, coherent understanding of the central concepts of the domain of TWAW that is sufficient to distinguish the salient features of the inter-relationships of the concepts in order to support the arguments made in the rest of the paper. Three points are emphasised in this respect:

- The core conceptualisation does not attempt to be exhaustive, ie it does not aim to give complete coverage of the domain that it addresses. For example, there may be processes by which meaning can be derived other than knowing, feeling, willing and thinking;
- Not all of the concepts involved in the core conceptualisation are defined. As in all such theoretical work, some concepts are treated as being axiomatic, ie they are regarded as being self-evident and thus do not require definition. Important examples include representation, faculty, etc. Furthermore, some of the concepts involved are introduced by suggestion rather than by being fully articulated in well-formed definitions[65]. The most important examples of these are knowing, feeling and willing;
- Although the core conceptualisation is not (richly) pluralistic, this should not be taken as implying that it is monistic. Although the core conceptualisation provides just a single view of its domain, it does not purport to be the only view that is valid or relevant.

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[62] In this work, the term "conceptualisation" is used to refer to "a system of ideas".

[63] See *Understanding Architecture*, [Burke 2000], for an exposition of this new field.

[64] See *Understanding Architecture*, Appendix C, [Burke 2000], for definitions of the terms "pluralism" and "monism" and an introduction to Sir Isaiah Berlin's views on the importance of pluralism in human affairs. See Berlin, [Berlin 1979; Berlin 1990], for a fuller exposition of these ideas.

[65] In *A Short History of Chinese Philosophy*, [Yu-Lan 1948], Fung Yu-Lan describes how "suggestiveness, not articulateness, is the ideal of all Chinese art." He remarks on the apparent "briefness and disconnectedness" of Chinese philosophical works and how this differs from the elaborate reasoning and detailed argument characteristic of most Occidental philosophy.

The major features of the core conceptualisation are:

- Meaning is arguably the single most important issue in the domain; the conceptualisation is dominated by what is involved in assigning, deriving and sharing meaning by Information Systems, Knowledge Systems, Thought Systems, etc;
- Recursive relationships of intelligence/computing, cognition/knowing, consciousness/thinking, etc give rise to hierarchies of levels of complexity in Information Systems, Knowledge Systems, Thought Systems, etc;
- Some of the concepts are extensively inter-related. For example, consider how the concept of schema is inter-woven through the conceptualisation:
  - a schema is what is understood to be common to the members of a set;
  - schema processing is the essence of thinking; it is how meaning is derived from information;
  - schema is a central concept in complexity; it is used to describe a system's regularities;
  - complexity is a central concept in system; it characterises the system's emergent properties;
  - systems hierarchy is an architecture view of a system; it highlights the different levels of complexity in a system;
  - architecture is what we understand about a system, ie it is the meaning derived from a system through thinking/schema processing.

It is emphasised that the core conceptualisation does not commit to a "mind as machine" metaphor in which cognition and thought are considered to be merely information processing activities. It adopts a radically different stance: it assumes that "meaning matters".

3 Architecture Description of Thought Systems

'Art is solving problems that cannot be formulated before they have been solved. The shaping of the question is part of the answer.'

Piet Hein

The paper uses simple architecture descriptions, in particular the Knowledge Systems View, to frame a discussion of the (potential) significance of different forms of Thought System and their emergent properties.

The Knowledge Systems View is an architecture description that highlights the Knowledge System aspects of the Thought Systems with which it is concerned. (*Understanding Architecture,* [Burke 2000], provides a detailed explanation of these concepts.)

The primary purpose of Section 3 is to introduce a coarse schema for the Knowledge Systems View of Thought Systems that will be used in other parts of the paper. It discusses the basis and reasoning behind the schema and illustrates how it can be used to describe Thought Systems.

3.1 Knowledge Systems View Schema

Figure 13 presents the coarse schema for the Knowledge Systems View of Thought Systems that is proposed.

Dimension	Indicative values
KS Component Type:	human, biological, hybrid, non-natural
Group Size:	one, two, few, several, organisation, collective
Sharing (process):	none, data, information, knowledge
Sharing (product):	none, data, information, knowledge
Coordination:	none, replication, constraint, trust, voting, anarchy
Distribution:	common, local, remote
Diversity:	uniform, mixed, disparate

Figure 13 A Knowledge Systems View Schema

The schema describes Knowledge Systems in terms of indicative "values" on seven distinct "dimensions". Typically, all seven dimensions are used in making a description of any particular Thought System. It is possible that a Thought System can have more than one value on a given dimension.

Each of the dimensions and its indicative values are discussed in turn in the following paragraphs. The following simple and commonplace example is used to illustrate the discussions.

Example: Consider two people accessing an article posted on a website: the author of the article and someone not involved in writing the article. The people can be thought of as the Knowledge System components of a composite Thought System[66].

The use of the schema is then illustrated using the following as examples of Thought Systems:

- a single ant;
- an ant colony;
- the Zapatista social netwar described in the Introduction.

3.1.1 KS Component Type

KS Component Type describes the nature of the Knowledge System components in a Thought System. Section 2 has suggested that there are two major categories of Knowledge System namely Natural Knowledge Systems and Artificial Knowledge Systems. The indicative values "human" and "biological"[67] reflect two mutually exclusive sub-categories of Natural Knowledge Systems. The indicative values "hybrid" and "non-natural" reflect two mutually exclusive sub-categories of Artificial Knowledge Systems.

This aspect of the Thought System in the website example is described using the Knowledge Systems View schema as follows.

KS Component Type: ***human***, biological, hybrid, non-natural

3.1.2 Group Size

Group Size describes the number of Knowledge System components in a Thought System. Thought Systems that have only one Knowledge System component differ significantly from those that have more than one Knowledge System component; the former typically does not depend on information as a communication medium whereas the latter typically does. Accordingly, there is a profound difference between cognition that emerges from Thought Systems with a single Knowledge System component and those with multiple Knowledge System components. For example, the cognition of an individual human being is fundamentally different from that of a group of human beings working collaboratively as a team - even if the group size is just two people. Although there is reason to believe that high levels of consensus can be achieved, no two people have ever yet shared the same thought. (See Appendix A and *Understanding Architecture* for a discussion of this.)

[66] The composite Thought System has other types of component apart from Knowledge System components. In particular, its Information System and Data System components constitute the infrastructure that supports the World Wide Web.
[67] The term "biological" is intended to convey the meaning "natural but non-human".

Judging by the nature of cognition that emerges from them, significantly different levels of system complexity would appear to exist in Thought Systems with different Group Sizes. It is hypothesised that a hierarchy of system complexity may exist in this respect. It is conjectured that the indicative values "one", "two", "few", "several", "organisation" and "collective" may reflect qualitatively different levels in such a hierarchy of system complexity.

This aspect of Thought System in the website example is described using the Knowledge Systems View schema as follows.

Group Size:	one, ***two***, few, several, organisation, collective

3.1.3 Sharing (process) and Sharing (product)

Sharing (process) and Sharing (product) describe the nature of the sharing mechanisms of the Knowledge System components of a Thought System.

Sharing (process) describes the nature of any shared processes of "knowing"; Sharing (product) describes the nature of any shared products of processes of "knowing". Figures 1 and 2 and Table 1 and the following example are intended to clarify this distinction.

The indicative values for both Sharing (process) and Sharing (product) are "none", "data", "information" and "knowledge".

In the website example, the two people share the information encapsulated in the product (ie the article) of a knowing process (ie writing the article); only the author was involved in the knowing process that created the information. This aspect of the Thought System in the website example is described using the Knowledge Systems View schema as follows.

Sharing (process):	***none***, data, information, knowledge
Sharing (product):	none, data, ***information***, knowledge

3.1.4 Coordination

Coordination describes the nature of the mechanisms that influence interactions between[68] Knowledge System components in a Thought System. Various mechanisms are possible.

In some simple Thought Systems, eg with only one Knowledge System component, no interaction is involved and therefore no coordination mechanism is needed. In such extreme cases, coordination is perfect and does not depend on information exchange. In future Artificial Thought Systems involving multiple Knowledge System components, it is conceivable that sharing and/or replication of (some) Knowledge System components may be a design feature intended to improve coordination and reduce information exchange.

[68] Note that Coordination does not describe the mechanisms of the internal interactions of the Knowledge System components of Thought Systems.

In Thought Systems with multiple Natural Knowledge Systems components coordination occurs by the Knowledge Systems components complying with some form of protocol. Such protocols depend on the exchange and interpretation of information. The protocols can be based on (combinations of) different forms of:

- imposed, rule-based and/or power-based authority;
- voluntary trust-based relationships;
- voting strategy including consensus formation.

If there is no coordination mechanism in Thought Systems involving multiple Knowledge System components, then anarchic interaction results.

The indicative values for the Coordination dimension are therefore "none", "replication", "constraint", "trust", "voting" and "anarchy".

This aspect of the Thought System in the website example is described using the Knowledge Systems View schema as follows.

Coordination:	***none***, replication, constraint, trust, voting, anarchy

3.1.5 Distribution

Distribution describes the extent of the physical dispersion of the Knowledge System components in a Thought System. Thought Systems that have common Knowledge System components differ profoundly from those with Knowledge System components that are physically distinct. Physically distinct Knowledge System components must communicate using some information medium. There is an inter-dependence between the proximity of physically distinct Knowledge System components and the nature of the information medium by which they communicate. The indicative values for the Distribution dimension are therefore "common", "local" and "remote".

This aspect of the Thought System in the website example is described using the Knowledge Systems View schema as follows.

Distribution:	common, local, ***remote***

3.1.6 Diversity

Diversity describes the degree of dissimilarity of the Knowledge System components in a Thought System. Thought Systems that have similar Knowledge System components tend to use information to express themselves in ways that are likely to be understood consistently by each other and interpret information in roughly the same ways. This is not the case for Thought Systems that have disparate Knowledge System components. Accordingly, the indicative values for the Diversity dimension are therefore "uniform", "mixed" and "disparate".

This aspect of the Thought System in the website example is described using the Knowledge Systems View schema as follows.

Diversity:	uniform, ***mixed, disparate***

3.2 Examples

3.2.1 Website

The Thought System in the website example is described in Figure 14 using the complete Knowledge Systems View schema as follows.

KS Component Type:	***human***, biological, hybrid, non-natural
Group Size:	one, ***two***, few, several, organisation, collective
Sharing (process):	***none***, data, information, knowledge
Sharing (product):	none, data, ***information***, knowledge
Coordination:	***none***, replication, constraint, trust, voting, anarchy
Distribution:	common, local, ***remote***
Distribution:	common, local, ***remote***
Diversity:	uniform, ***mixed, disparate***

Figure 14 Description of the Website Example using the Knowledge Systems View Schema

3.2.2 Ant

An ant is a biological entity with primitive cognitive, volitional and emotional functions. An ant's cognitive function is largely genetically determined although it does have an unsophisticated ability to learn from experience.

Figure 15 illustrates how the Knowledge Systems View schema is used to describe a single ant when regarded as a Thought System.

KS Component Type: human, ***biological***, hybrid, non-natural
Group Size: ***one***, two, few, several, organisation, collective
Sharing (process): ***none***, data, information, knowledge
Sharing (product): ***none***, data, information, knowledge
Coordination: ***none***, replication, constraint, trust, voting, anarchy
Distribution: ***common***, local, remote
Diversity: ***uniform***, mixed, disparate

Figure 15 Description of an Ant using the Knowledge Systems View Schema

3.2.3 Ant Colony

An ant colony is a biological collective composed of a large number of ants. The population of a colony is usually, but not always, drawn from a single species. Generally, a colony has more than one caste (or class) of ant, eg queens, workers, soldiers, etc. that perform distinct sets of functions. The ants in a colony communicate with one another using non-linguistic data and information, eg pheromone signs. An ant colony exhibits various emergent properties that are qualitatively different from the properties of the individual ants in the colony. In particular, an ant colony can exhibit cognitive, volitional and emotional faculties that differ significantly from those of any of its individual ants[69]. Examples of such faculties include those consistent with a colony's ability:

- to build and maintain complicatedly structured nests;
- to identify and collectively access remote sources of nutrition;
- to "swarm" as part of strategies for relocating and reproducing;
- to display complex social behaviours such as "enslaving" the ants of other species.

Figure 16 illustrates how the Knowledge Systems View schema is used to describe an ant colony when regarded as a Thought System.

KS Component Type: human, ***biological***, hybrid, non-natural
Group Size: one, two, few, several, organisation, ***collective***
Sharing (process): ***none***, data, information, knowledge
Sharing (product): none, ***data***, ***information***, knowledge
Coordination: none, replication, ***constraint***, trust, voting, anarchy
Distribution: common, ***local***, remote
Diversity: **uniform**, ***mixed***, disparate

Figure 16 Description of an Ant Colony using the Knowledge Systems View Schema

[69] See Bonabeau, Dorigo and Theraulaz, [Bonabeau, Dorigo et al. 1999], for a discussion of social insect behaviour and the emergent property of insect colonies known as "swarm intelligence".

3.2.4 Zapatista Social Netwar

Figure 17 illustrates how the Knowledge Systems View schema is used to describe the Thought System constituted by the EZLN supporters in the Zapatista social netwar described in the Section 1.

KS Component Type:	***human***, biological, hybrid, non-natural
Group Size:	***one***, two, few, several, organisation, ***collective***
Sharing (process):	***none***, data, information, knowledge
Sharing (product):	none, data, ***information***, knowledge
Coordination:	none, replication, constraint, ***trust***, voting, anarchy
Distribution:	common, local, ***remote***
Diversity:	uniform, ***mixed***, ***disparate***

Figure 17 Description of the EZLN Thought System using the Knowledge Systems View Schema

3.3 Discussion

It is appreciated that such a coarse schema does not "span" the set of all possible Knowledge Systems, ie it cannot provide full descriptions of all Knowledge Systems. The schema aims to provide sparse descriptions of Knowledge Systems sufficient to highlight their major distinguishing features.

Known deficiencies of the schema include:

- its failure to distinguish between the bases of sharing of data, information and knowledge <u>products</u>. For example:
    - Transmit only; receive only; transmit and receive only
    - 1 to 1; 1 to many; many to 1 etc.
- its inability to characterise sharing and coordination on the basis of the temporal parameters of the mechanisms involved. For example, real-time interaction is a much more dynamic mode of coordination than "snail-mail" based review feedback request/response.

Note that dividing the dimensions of the schema using the indicative values in the way described above suggests that there are a very large number, N_{TS}, ($N_{TS} \sim 10^4$) of distinct categories of Thought System that can be distinguished within the Knowledge Systems View. If the dimensions were orthogonal, then $N_{TS} = 20736$. However, this is not the case. For example, if Group Size has the value "one", then the values of Coordination, Distribution and Diversity <u>must be</u>, "none", "common" and "uniform" respectively.

Given that the Knowledge Systems View elides all information concerning Data Systems, Information Systems, Feeling Systems and Will Systems, it follows that the total number of distinct categories of Thought System must be very large indeed.

It would be possible to augment the description of Thought Systems afforded by the Knowledge Systems View by developing Architecture Views that highlight aspects of Feeling Systems, Will Systems, Information Systems and Data. Although the Thought Systems descriptions produced using multiple Architecture Views from perspectives such as these would be more comprehensive than those produced using just the Knowledge Systems View, they would also be very much more complex. It was judged that it was neither necessary nor appropriate to do this in an introductory paper of this sort since it would it make an already complicated exposition even more involved and thus run the risk of obfuscating the major issues.

4 Current Thought Systems

'Most people would die sooner than think – in fact, they do so.'

Bertrand Russell

This Section provides insight into the prevailing architectural characteristics of current Thought Systems in terms of the typical characteristics and inter-relationships of their Data Systems, Information Systems, Knowledge Systems, Will Systems and Feeling Systems components. Examples discussed include:

- Human minds
- Composite Thought Systems in Defence
- Collective Intelligence
- *Ba*

The Section argues that the collaboration of groups of people on thought-based tasks is currently extremely communication intensive and is usually both ineffective and inefficient. It argues that reliance on information sharing is the cause of the most significant deficiencies of current Thought Systems.

4.1 Human Minds

Human thought is currently conducted on an individual basis. Thoughts are never shared directly; thinking is never done jointly, [Jarvis 1999], [Burke 2000]. Attempts to develop shared understanding within a group of people are based on the sharing of information. Such attempts involve the interaction of the group within some mutually accessible representational space; such spaces are usually realised as Information Systems and/or Data Systems. Different mechanisms for interaction exist. Some form of coordination is involved; coordination is based on information sharing. Most commonly, this relies on some degree of consensus being formed but this is not always the case. Different mechanisms for consensus formation exist. The collaboration of groups of people on thought-based tasks currently relies on distributing aspects of the task amongst individuals in the group; some aspects, eg consensus formation, need to be addressed by more than one member of the group. Wide diversity can exist in (the aspects of) the thought-based tasks addressed (by members) of the group. Some thought-based tasks can be too large for a single person to address successfully; some can be too complex for a group to be coordinated to address together successfully.

For example, if I know that my friend has an excellent memory for 'phone numbers and I decide that I need to call someone whose number I currently don't know but I am confident that she does, then I can ask her for it and then I can use it. This is an example of collaborating on a simple cognitive task. It involves sharing of information produced by cognitive processes but does <u>not</u> involve any directly shared cognitive processes. Its key feature is that I know (to some level of confidence) that my friend knows something that I don't know and that I need to know in order to proceed with my planned action.

When regarded as a Thought System, the individual human mind can be described using the provisional Knowledge Systems View schema as shown in Figure 18.

KS Component Type:	***human***, biological, hybrid, non-natural
Group Size:	***one***, two, few, several, organisation, collective
Sharing (process):	***none***, data, information, knowledge
Sharing (product):	***none***, data, information, knowledge
Coordination:	***none***, replication, constraint, trust, voting, anarchy
Distribution:	***common***, local, remote
Diversity:	***uniform***, mixed, disparate

Figure 18 Description of the Individual Human Mind using the Knowledge Systems View Schema

Comments

- Unsophisticated thought-based activities are conducted by some non-human, biological entities. For example, chimpanzees have the capacity to learn, to remember, to reason etc. Boulding, [Boulding 1956], provides telling insights on this issue.
- There is ongoing debate concerning whether artificial Knowledge Systems components (can) exist. Note, for example that Jarvis, [Jarvis 1999], and Burke, [Burke 2000], hold different opinions in this regard. Notwithstanding this, there is considerable accord that, irrespective of whether artificial Knowledge Systems can be anticipated to perform some role in Knowledge Systems, the majority of important cognitive work in Knowledge Systems will be conducted by human minds and that the most adaptive element in Knowledge Systems will remain the human mind.
- Note that currently there is no form of direct sharing in thought-based processes at any level.

4.2 Composite Thought Systems in Defence

There are various Thought Systems in Defence that have more than one Knowledge System, Will System and Feeling System component. Examples discussed include:

- ADHQ
- HQAST
- C4ISREW Systems

A wide diversity of different types of Data System and Information System are involved as components of these Thought Systems[70]. Modern telecommunications and information technologies play an increasingly important role in the synthesis of such components. The strategic significance of these issues is widely appreciated and is reflected in current

[70] Les Vencel, a Joint Systems Branch contractor, has prepared a comprehensive relational database of the ADF's C4ISREW systems assets, [Vencel 2000].

Australian Strategic Policy, [Defence 1997] and in Defence's initiatives in respect of the Revolution in Military Affairs, [ORMA 1999].

In contrast, there is only one type of Knowledge System, Will System and Feeling System component of any significance in current Thought Systems in Defence: groups of human minds are always the most important, and usually the only, type of Knowledge System, Will System and Feeling System components involved. The group size is always at least one, but has no theoretical upper limit.

It is noteworthy that, just as in other forms of war and anti-war, group human emotion and group human volition are vital issues in TWAW. Very large groups of people, typically measured in millions, are involved in these matters. For example, a recent survey of senior ADF officers, [Fairs 1999], found that they considered that the most significant factor affecting the outcome of future conflict involving Australia was the current trend in Australian society of "not having the will to fight (sustained) wars".

Propaganda, "Media War" and the so-called "CNN effect" are also primarily emotional and volitional phenomena that prevail in massive groups of people. Media War is recognised as having a profound effect on both the conduct of modern military conflict and its avoidance. Stourton's discussion of the Media War in the Kosovo conflict, [Stourton 1999][71], provides valuable insights into this phenomenon.

If the volitional and emotional aspects of TWAW can be influenced by Defence Thought Systems with very large numbers of Will System and Feeling System components, then this contrasts starkly with the cognitive aspects. Individual human cognition is the most significant form of cognition to currently have a bearing on Thought Systems in Defence. Due to the reliance on information sharing as a means of mediating thought-based activities, group human cognition, regarded as an emergent property of a Thought System whose components include more than one Knowledge System component, is extremely inefficient and ineffective.

4.2.1 C4ISREW Systems

Both the conceptual and practical implications of this phenomenon are reflected in the approach that Defence has taken to date towards C4ISREW, (Communications, Command, Control, Computers, Information, Surveillance, Reconnaissance and Early Warning) and the related C4I, C3ISR, C3I, C2, etc issues.

Simplistically stated, the conceptual basis of C4ISREW is that battlespace data and information are provided to groups of people who make decisions regarding action to be taken to change the state of that battlespace. Information is used as the exclusive medium in coordinating the thought-based activities of such groups and in communicating their decisions to agents that attempt to act on them.

[71] This article can be accessed at the following website:
http://www.telegraph.co.uk/et?ac=001133997017675&rtmo=r3F9EbkX&atmo=r3F9EbkX&pg=/et/99/10/16/tlnato16.html

It is contended that the architecture of most C4ISREW Systems to date have been devised in the tacit assumption that group human cognition will be extremely poor. Reliance is instead vested in the cognitive abilities of very small groups of key individuals playing leadership roles; such individuals also usually possess highly developed volitional and emotional capacities. In particular, it is suggested that this contention is supported by the prevalence of the hierarchy as the organisational structure of existing Command and Control systems and, indeed, in other forms of non-military system involving large numbers of human beings[72]. Examples include: the classic hierarchal structure of ADHQ; and the "J structure" of HQAST.

There are various important consequences of this assumption. These include the tacit need:

- to identify, educate and train small numbers of people with highly developed cognitive, volitional and emotional abilities to play decision-making and leadership roles in C4ISREW Systems
- to recruit, educate and train larger numbers of people with less highly developed thought-based abilities to play more action-oriented roles in C4ISREW Systems
- to develop a common culture within which shared understanding can be readily developed by all people involved in C4ISREW Systems.

Accordingly, the overwhelming explicit concern in addressing C4ISREW issues has been with the means by which:

- the decision-makers can be provided with information to support them in making apposite and timely decisions
- information that represents the decision-makers intentions can be conveyed faithfully to agents who will act on them.

As technological advances have been made that have helped address these largely Information Systems issues, then the importance of the associated Knowledge Systems issues has started to be appreciated more fully. A highly significant aspect of this is the phenomenon of so-called "information white-out" in which decision-makers are provided with a surfeit of poorly integrated information that is too difficult to assimilate and make sense of. (Both Baumard and Wilensky's remarks in this respect are noteworthy. See Appendix F for details.) Some important examples of this emerging trend are outlined below.

4.2.2 Situational Awareness

Situational Awareness is an issue that has conventionally been understood as being largely concerned with the development of a "common picture" of the battlespace; a picture that can be accessed as appropriate by all in the command chain. It is often conceived of as an issue of "getting the right information, to the right people at the right time"[73]. Recently,

[72] Note that the ROLF initiatives led by Prof. Berndt Brehmer of the Swedish National Defence College are currently researching radically different approaches that may revolutionise this situation. See for example, Brehmer, [Brehmer 1997].

[73] See for example, RADM Meyer's remarks, [Meyer 1998].

however, there has been a significant shift away from this information-oriented view to a knowledge-oriented view that stresses the importance of the sense that users make of the information with which they are provided. In particular, RADM Briggs[74], has recently defined situational awareness in terms of "shared understanding", [Briggs 1998]. Within the conceptual/terminological framework of this paper, there are two extremely important ramifications of this conception. Firstly, it suggests that Situational Awareness is not just an Information Systems issue but rather an issue that involves the interaction of at least Knowledge Systems and Information Systems. Secondly, it suggests that there is no need for all the people involved in a C2 system to have the same understanding, ie a common understanding, of the battlespace but rather to share understanding of those aspects of the battlespace that are relevant to their particular roles in the C2 system.

4.2.3 Communication of Intent

Inefficiencies in the communication of a commander's intent have been recognised as a major problem in Defence Systems for a long time. An apparently frivolous, but nevertheless poignant, example of the phenomenon is provided by the well-known joke from World War I in which the order "Send reinforcements. We're going to advance." is distorted in being passed man-to-man along the trenches to become "Send three and fourpence. We're going to a dance." In the modern era, advances in telecommunications technology have greatly improved the reliability of the transmission and reception of messages, however, serious problems continue to exist in respect of how messages are interpreted. For example, results from simulations indicate that even though military Command and Control systems have a specified method to communicate intent, company commanders were able to match their battalion commanders intent in only 34% of thirty-two episodes, [Shattuck and Woods 1999].

4.2.4 Systems of Systems

Many issues relating to the RMA, especially those in respect of force development and joint operations, involve Systems of Systems. CDS, Dr Brabin-Smith, has described them as follows, [Brabin-Smith 1999].

> *'Many of these issues relate to the Revolution in Military Affairs (RMA) and are often referred to as System of Systems issues. These issues arise as Defence assembles various combinations of naval platforms, aircraft and army units for operations, either with the force-in-being or with some potential future force. Advances in surveillance and in command and communication systems offer the potential to integrate such systems in ways not previously possible, and to achieve synergistic benefits, but at a cost of increased complexity and in ways as yet difficult to quantify.'*

Appendix I offers brief definitions and explanations of some of the key concepts relating to System of Systems and Joint Systems. From this it can be abduced that Joint Systems are Thought Systems involving high degrees of integration and complexity.

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[74] At that time, RADM Briggs held the position of Head, Strategic Command Division in Australian Defence Headquarters.

4.2.5 Way of Warfighting

COMAST's "Decisive Manoeuvre: Australian Warfighting Concepts to Guide Campaign Planning', [Defence 1998], emphasises the need for a shared vision of the Australian way of warfighting. It notes that this is currently addressed through the development of a "band of brothers"[75] ethos. It is suggested that this is primarily a Thought Systems issue in which Information Systems and Data Systems concerns are of secondary importance: a cultural phenomenon rather than a technological one.

An example of this phenomenon is provided by an article on the front-page of *The Australian* newspaper published immediately prior to the embarkation of the Australian-led peace-enforcement mission to East Timor, [Toohey 1999]. The article summarises an interview with three anonymous soldiers concerning their thoughts regarding what lay before them. It concluded: "These men think the same, talk the same. In other words, they're ready".

4.2.6 Summary

The current status of Thought Systems in Defence in general is summarised in Figure 19 using the provisional Knowledge Systems View schema.

KS Component Type:	***human***, biological, hybrid, non-natural
Group Size:	***one, two, few, several, organisation***, collective
Sharing (process):	***none***, data, information, knowledge
Sharing (product):	none, ***data, information***, knowledge
Coordination:	none, replication, ***constraint, trust, voting***, anarchy
Distribution:	common, ***local***, remote
Diversity:	***uniform, mixed***, disparate

Figure 19 Description of a Current Thought Systems in Defence using the Knowledge Systems View Schema

[75] It is interesting to note that this term is taken from Shakespeare's play *King Henry the Fifth*, (Act IV, Scene III), [Shakespeare 1994], in which the King addresses his men prior to their great victory over the French at the Battle of Agincourt. The King, having just returned from making his own reconnoitre of the battlefield in which he established that his force was outnumbered by five to one, rouses his followers into concerted action. It is perhaps drawing a long bow(!), but it would seem that although such aspects of the way of warfighting have changed fundamentally since then, others have not. His reply to a warning of the expedience of the French charge is: "All things are ready, if our minds be so" – surely an equally apt admonition in an era of Thought War as it was in former times!

Comment

- In the assumption that the provisional Knowledge Systems View schema is valid, this suggests that Defence is currently exploiting just 60 of the N_{TS} distinct Thought Systems categories.

4.3 Collective Intelligence

The keys ideas introduced by Levy in his book *Collective Intelligence,* [Levy 1997], are summarised below.

A cosmopedia is a dynamic and interactive multi-dimensional representational space enabled by modern communications and information technologies; it is a network of Data and Information Systems. A cosmopedia mediates the interaction of very large numbers of individual Thought Systems; the most common type of Thought System involved being individual human minds. Systems synthesised in this way will be referred to in this paper as Collective Thought Systems. Note that this is not a term used by Levy.

Collective Intelligence is an emergent property of a Collective Thought System that results from the interaction of the thought-based activities of component Thought Systems mediated by a cosmopedia. It is distributed, anarchic consciousness that relies on the sharing of information; it is a Thought Systems and Culture Systems[76] issue.

Note that within the conceptual/terminological framework of this paper, the term "Collective Consciousness"[77] is a more appropriate label for the concept that Levy refers to as "Collective Intelligence".

The Thought System constituted by Levy's notion of Collective Intelligence is summarised in Figure 20 using the provisional Knowledge Systems View schema.

KS Component Type:	***human***, biological, hybrid, non-natural
Group Size:	one, two, few, several, organisation, ***collective***
Sharing (process):	none, ***data, information***, knowledge
Sharing (product):	none, ***data, information***, knowledge
Coordination:	none, replication, constraint, trust, voting, ***anarchy***
Distribution:	common, ***local, remote***
Diversity:	uniform, ***mixed, disparate***

Figure 20 Description of the Collective Intelligence using the Knowledge Systems View Schema

[76] See Jarvis, [Jarvis 1999], for a discussion of the significance of Culture Systems in the Australian Defence context.

[77] Toffler and Toffler, [Toffler and Toffler 1993], p115, use the term "collective consciousness" to describe a possible emergent property of "mega-robots", ie groups of intelligent, inter-communicating and autonomous robots.

4.4 Ba

The key ideas relating to the concept of "*ba*" introduced by Nonaka and Konno, [Nonaka and Konno 1998 (Spring)] are summarised below.

Ba is a shared space for emerging relationships. This space can be physical, virtual, mental or any combination of them. *Ba* is a context that harbours meaning. It serves as a foundation for knowledge creation. Knowledge is embedded in *ba*, where it is then acquired through an individual's experience or reflections on the experiences of others. Knowledge separated from *ba* is information and can be communicated independently from *ba*. Information resides in media and networks; it is tangible. Knowledge resides in *ba*; it is intangible.

Nonaka and Takeuchi, have proposed that knowledge creation is a "spiralling process of interactions between explict and tacit knowledge", [Nonaka and Takeuchi 1995] Their SECI Model suggests that there are four (dominant) knowledge conversion processes:

- Socialisation;
- Externalisation;
- Combination;
- Internalisation

Note that the author has been led to believe that the Office of the RMA is using the SECI model as its "knowledge creation process", [Goodyer 1999].

There are four types of *ba* that correspond to the four stages of the SECI Model. These are:

- Originating *ba;*
- Interacting *ba;*
- Cyber *ba;*
- Exercising *ba.*

The Thought Systems constituted by these four types of *ba* are summarised in Figures 21 - 24 using the provisional Knowledge Systems View schema. It is emphasised that these summaries are the author's interpretation of the characteristics of the *ba*. At a terminological level at least, they do not accord in all respects with Nonaka and Konno's descriptions of the *ba*. There is at least one important conceptual difference: Nonaka and Konno consider that both tacit and explicit knowledge can be shared directly; this author does not consider this to be the case. The author's views on this have been summarised above and are elaborated in Appendix A of this paper and in *Understanding Architecture, [Burke 2000].*

4.4.1 Originating *ba*

KS Component Type: ***human***, biological, hybrid, non-natural
Group Size: one, ***two***, ***few***, ***several***, organisation, collective
Sharing (process): ***none***, data, information, knowledge
Sharing (product): none, ***data***, information, knowledge
Coordination: none, replication, constraint, ***trust***, voting, anarchy
Distribution: common, ***local***, remote
Diversity: ***uniform***, mixed, disparate

Figure 21 Description of Originating Ba using the Knowledge Systems View Schema

4.4.2 Interacting *ba*

KS Component Type: ***human***, biological, hybrid, non-natural
Group Size: one, ***two***, ***few***, ***several***, ***organisation***, collective
Sharing (process): ***none***, data, information, knowledge
Sharing (product): none, data, ***information***, knowledge
Coordination: none, replication, ***constraint***, trust, voting, anarchy
Distribution: common, ***local***, ***remote***
Diversity: uniform, ***mixed***, disparate

Figure 22 Description of Interacting Ba using the Knowledge Systems View Schema

4.4.3 Cyber *ba*

KS Component Type: ***human***, biological, hybrid, non-natural
Group Size: one, two, few, several, ***organisation***, collective
Sharing (process): none, ***data***, ***information***, knowledge
Sharing (product): none, ***data***, ***information***, knowledge
Coordination: none, replication, ***constraint***, trust, voting, anarchy
Distribution: common, ***local***, ***remote***
Diversity: uniform, ***mixed***, disparate

Figure 23 Description of Cyber Ba using the Knowledge Systems View Schema

4.4.4 Exercising *ba*

KS Component Type:	***human***, biological, hybrid, non-natural
Group Size:	one, ***two***, ***few***, ***several***, ***organisation***, collective
Sharing (process):	none, ***data***, ***information***, knowledge
Sharing (product):	none, data, ***information***, knowledge
Coordination:	none, replication, ***constraint***, trust, voting, anarchy
Distribution:	common, ***local***, remote
Diversity:	***uniform***, mixed, disparate

Figure 24 Description of Exercising Ba using the Knowledge Systems View Schema

4.4.5 Comments

A separate paper would be required to fully discuss, and to compare and contrast, the concepts of Collective Intelligence, cosmopedia and *ba*. This may even be an appropriate topic for a Masters thesis in a discipline such as Knowledge Management, Cultural Studies, Anthropology etc.

5 Future Thought Systems

'The idea of progress always precedes development.'

Kenneth Boulding,
[Boulding 1956], p122

Forecasts by Toffler and Toffler, Nonaka and Konno, Levy and others regarding the nature of future Thought Systems derive principally from their expectations regarding the development of Data Systems and Information Systems rather than Knowledge Systems, Will Systems or Feeling Systems. This Section postulates that revolutionary changes in Thought Systems would occur if means could be developed that enable shared understanding to be formed that do not rely on information sharing (to the same extent). It also speculates on the nature of future Thought Systems that would be possible if different means of distribution and coordination can be developed.

Radically different ways of "thinking together" will be proposed and discussed in this Section. These are:

- Knowledge Sharing Artificial Thought Systems
- Collective Thought Systems
- Coordinated Collective Thought Systems
- Empathetic Thought Systems
- Sympathetic Thought Systems
- Pluralistic Thought Systems

Comments will be made regarding the architectural characteristics, emergent properties and relative capabilities of such systems. The significance to Defence of these new forms of Thought Systems will be discussed briefly.

This Section will be principally concerned with the implications of the development of new modes of communication for Thought Systems. Although it will indicate means by which such advances could be realised, this will not be its explicit focus. However, where appropriate, reference will be made to Appendices that address how possible means could be identified and developed. It will assume, however, that Artificial Knowledge Systems can be anticipated to perform some role in Knowledge Systems but the majority of important thought-based work in Knowledge Systems will continue to be conducted by human minds. It will assume that the most adaptive element in Knowledge Systems will remain the human mind.

5.1 Knowledge Sharing Artificial Thought Systems

If Non-Natural Knowledge Systems can be synthesised, then it will be possible to create radically different Thought Systems that exploit (some degree of) direct knowledge sharing. Direct knowledge sharing would occur, for example, if a Non-Natural Knowledge System were to be common to two or more higher level Thought Systems components.

Accordingly, a Knowledge Sharing Artificial Thought System is defined as an Artificial Knowledge System that exploits (some degree of) direct knowledge sharing.

Thought Systems that exploit direct knowledge sharing would not need to rely on information sharing as a means of communication and coordination to the same extent as conventional Thought Systems. This would be highly beneficial for many complex Thought Systems applications. Candidate examples include:

- Knowledge Fusion
- Knowledge Management
- Collaborative Work
- Decision Support

5.1.1 Comments

Artificial Intelligence (AI) has been defined, [Sowa 1984], "as the study of knowledge representations and their use in language, reasoning, learning and problem solving. AI programs gain flexibility over conventional systems by using a changing knowledge base rather than a fixed, pre-programmed algorithm."

Note that this definition is <u>not</u> consistent with the conceptual/terminological framework of this paper. Within the framework, the term "the study of Knowledge Systems" is a more appropriate label for the concept that Sowa refers to as "Artificial Intelligence". Similarly, the term "Non-Natural Knowledge System" would be used instead of "AI program".

It is also noteworthy that Sowa's definition is typical of mainstream AI in that it makes the inherent assumption that thought is an information processing activity.

5.2 Collective Thought Systems

The notions of Collective Intelligence and cosmopedia have been proposed by Levy, [Levy 1997], and are discussed in Section 4 above. Section 4 suggested that Collective Intelligence is an emergent property of a Collective Thought System resulting from the interaction of the thought-based activities of component Thought Systems mediated by a cosmopedia.

Note that a key difference between Artificial Intelligence and Collective Intelligence is that Artificial Intelligence is intended to be an emergent property of an entirely artificial Thought System whereas Collective Intelligence is an emergent property of a network of (predominantly) human Thought Systems.

Collective Thought Systems typically involve huge amounts of data- and information-processing. Consequently, the capability of a Collective Thought System relies heavily on the capabilities of its Data System and Information System components.

The dominant architectural characteristics of Collective Thought Systems include:

- extremely large group sizes
- extremely high levels of data and information usage

- poor levels of coordination
- widespread distribution
- extremely high levels of diversity

Given the increasing extent to which the Australian people are "wired"[78], the opportunity exists to synthesise large-scale nationally distributed networks of military and civilian analysts. A form of Collective Intelligence could be expected to emerge from Collective Thought Systems of this type that could be made use of in Defence applications. For example, Collective Thought Systems could be expected to perform (or play a part in) low-fidelity, high-coverage functions with applications such as intelligence gathering, Information Operations, Information Warfare, surveillance, etc.

5.3 Coordinated Collective Thought Systems

Authier and Levy have proposed the notion of a "knowledge tree", [Authier and Levy 1992]. It is a computer-based method for the "overall management of skills" in organisations that is being experimented with diversely in several parts of Europe, especially France, [Levy 1997]. It is a means of representing the "organised multiplicity of skills available in a community", [Levy 1997], and how this develops over time.

Expressed in the terminology adopted by this paper, knowledge trees are Information Systems that contain information about Knowledge Systems. Information about a Knowledge System is typically provided by the Knowledge System itself. Changes in the information held in the knowledge tree reflect changes in the Knowledge Systems.

Knowledge trees provide a means of coordination within Collective Thought Systems; they provide a means of "constraining the anarchy" which usually prevails in such collectives. They enable a degree of "self-organisation" to occur within collectives that are not subject to any external constraints. Within formal organisations, ie in collectives that are subject to constraints, knowledge trees provide a means of monitoring and controlling the knowledge of the members of the organisation. In this sense, they can be considered as Knowledge Management tools.

'Within an organisation knowledge trees provide instruments for identifying and mobilising know-how, the evaluation of training, as well as a strategic vision of skill evolution and need.'

[Levy 1997], p260.

[78] Accordingly to a recent survey conducted by the Australian Bureau of Statistics, [ABS 1999], it was estimated that at November 1999, 25% of all households in Australia (1.7 million) had home Internet access, an increase of nearly 37%, or 477 000 households, on the November 1998 estimate where only 19% of households (1.3 million) has home Internet access. However, the proportion of households with a home computer has risen only slightly to nearly 50% of households (3.5 million) in November 1999 from 47% of households (3.2 million) in November 1998.

Coordinated Collective Thought Systems are Collective Thought Systems that employ some form of coordination of their component Knowledge Systems. They can be described in terms of the provisional Knowledge Systems View schema as shown in Figure 25.

Dimension	Indicative "divisions
KS Component Type:	***human***, biological, hybrid, non-natural
Group Size:	one, two, few, several, ***organisation, collective***
Sharing (process):	none, ***data, information***, knowledge
Sharing (product):	none, ***data, information***, knowledge
Coordination:	none, replication, ***constraint***, trust, voting, anarchy
Distribution:	common, ***local, remote***
Diversity:	uniform, ***mixed, disparate***

Figure 25 Description of Coordinated Collective Thought Systems using the Knowledge Systems View Schema

Coordinated Collective Intelligence is an emergent property of a Coordinated Collective Thought System.

The dominant architectural characteristics of Coordinated Collective Thought Systems include:

- large group sizes
- high levels of information usage
- weak levels of coordination through "self-organisation"
- widespread distribution
- very high levels of diversity

As such, Coordinated Collective Thought Systems could be expected to be applied in various Defence Knowledge Enterprises, eg ADHQ, ORMA, DSTO, Takari, etc.

5.4 Empathetic Thought Systems

empathy is defined, [Sykes 1977], as *"the power of projecting one's personality into (and so fully comprehending) (an) object of contemplation"*.

Empathetic Communication is envisaged as an information-sparse means of communication used to support collaboration on thought-based tasks. It is a tacit means of sharing information. For Empathetic Communication to be possible within a group of people, at least one member of the group must have the ability to sense what the others are doing or thinking with minimum information exchange.

A discussion of the basis of Empathetic Communication and how it could be realised is provided in Appendix B.

Empathetic Thought Systems are enabled by Empathetic Communication. They are characterised by cooperative, heterogenous thinking of a group of people (self-) orchestrated to achieve synergy. Empathetic Communication is the principal means of harmonisation (ie sharing and coordination) of the thought-based tasks of the group members. Other, more information rich, means of communication may also be used.

Empathetic Cognition and Empathetic Consciousness are emergent properties of Empathetic Thought Systems.

Amongst other things, the quality of Empathetic Cognition achievable by an Empathetic Thought System is dependent on:

- its group size
- the proportion of its group capable of Empathetic Communication. Mutual Empathetic Communication would be ideal but not necessary.
- the quality of Empathetic Communication achievable between the various sub-groups within its group
- the nature of the thought-based tasks being performed by its individual group members and the Empathetic Thought System when considered as a whole
- the "proximity" of the members of the group within the representational spaces/media in which they operate

Empathetic Thought Systems can be described in terms of the provisional Knowledge Systems View schema as shown in Figure 26.

KS Component Type:	***human***, biological, hybrid, non-natural
Group Size:	one, ***two***, ***few***, ***several***, organisation, collective
Sharing (process):	***none***, data, information, knowledge
Sharing (product):	none, data, ***information***, knowledge
Coordination:	none, replication, constraint, ***trust***, voting, anarchy
Distribution:	common, ***local***, ***remote***
Diversity:	uniform, ***mixed***, ***disparate***

Figure 26 Description of Empathetic Thought Systems using the Knowledge Systems View Schema

<u>Comments</u>

- KS Component Type: Empathetic Cognition is envisaged as a mode of cognition emerging through the interaction of "human" Thought Systems acting as components of an Empathetic Thought System. (It is conceivable, however, that humans could use some form of "artificial aids" to facilitate Empathetic Communication. In this case, it may be appropriate to consider Empathetic Cognition as a mode of cognition emerging from a system whose components are Hybrid Knowledge Systems.)
- Group Size: Empathetic Cognition is envisaged as a mode of cognition typically emerging from small groups of people. The typical group size anticipated ranges from two - several. Although not inconceivable, it is <u>not</u> anticipated that large groups,

particularly those of the scale of a "collective", will feature in Empathetic Thought Systems.

- Sharing (process): It is envisaged that no sharing of data, information or knowledge processes will necessarily be involved in Empathetic Thought Systems.
- Sharing (product): It is envisaged that information will be the primary shared product in Empathetic Thought Systems. Although there may be some sharing of data, no direct sharing of knowledge can take place.
- Coordination: Although other types of mechanism may be involved, trust is envisaged to be the dominant coordination mechanism in Empathetic Thought Systems. The factors involved in the development of such trust are discussed in Appendix B .
- Distribution: It is envisaged that the Knowledge System components of Empathetic Thought Systems will be physically distinct. Although it is conceivable that the distribution of these components could be remote, it is much more likely for them to be relatively local.
- Diversity: The principal value of Empathetic Systems is envisaged as resulting from the Empathetic Cognition that emerges when mixed or disparate Knowledge System components communicate empathetically. Although there may be value in the emergent properties of Empathetic Systems with uniform Knowledge System components, this is expected to be a secondary issue.

There are important differences between the relationships between the Knowledge Systems components and the Information Systems components of Empathetic Thought Systems and conventional Thought Systems. Empathetic Communication uses significantly different quantities and types of information than the mechanisms used in harmonisation in conventional systems: there is less of it but it is very subtle. This is largely an Information Systems issue. However, making sense of the information involved in Empathetic Communication requires sophisticated thought-based skills. This is a Knowledge Systems issue. The upshot is that the information processing overheads associated with harmonising in Empathetic Thought Systems are less than in conventional Thought Systems but much more highly adapted and adaptive Knowledge Systems are needed for this to be possible.

The dominant architectural characteristics of Empathetic Thought Systems can be anticipated to be:

- small group size
- high adaptability
- dynamic coordination
- low redundancy
- rapidly (re-)configured

The Knowledge System components of Empathetic Thought Systems will be able to know what each other is thinking. This contrasts with conventional Thought Systems in which the best that can be expected is that the Knowledge System components are confident that they have guessed correctly what the others are thinking.

Empathetic Thought Systems could be expected to enable radical changes in C4ISREW, especially in respect of the structure, staffing and operation of Command Centres.

5.5 Sympathetic Thought Systems

sympathy is defined, [Sykes 1977], as *"the capacity to be simultaneously affected with the same feeling as another"; "tendency to share or state of sharing another person's or thing's emotion or sensation or condition", "mental participation with another in his trouble or with another's trouble", etc.*

Sympathetic Communication is envisaged as an information-free means of communication used to support collaboration on thought-based tasks. It can be either an explicit or tacit means of sharing information and knowledge processes. For Sympathetic Communication to be possible within a group of people, at least one member of the group must have the ability to sense what the others are doing or thinking without information exchange.

A discussion of the basis of Sympathetic Communication and how it could be realised is provided in Appendix C.

Sympathetic Thought Systems are enabled by Sympathetic Communication. They are characterised by cooperative, heterogenous thinking of a group of people (self-) orchestrated to achieve synergy. Sympathetic Communication is the principal means of harmonisation (ie sharing and coordination) of the thought-based tasks of the group members. Other, more information rich, means of communication may also be used.

Sympathetic Cognition is an emergent property of a Sympathetic Thought System.

The quality of Sympathetic Cognition achievable by a Sympathetic Thought System depends on, amongst other things:

- its group size
- the proportion of its group capable of Sympathetic Communication. Mutual Sympathetic Communication would be ideal but not necessary.
- the quality of Sympathetic Communication achievable between the various sub-groups within its group
- the nature of the thought-based tasks being performed by its individual group members and the Sympathetic Thought System when considered as a whole
- the "proximity" of the members of the group within the representational spaces/media in which they operate

Sympathetic Thought Systems can be described in terms of the provisional Knowledge Systems View schema as shown in Figure 27.

KS Component Type:	***human***, biological, hybrid, non-natural
Group Size:	one, ***two***, ***few***, several, organisation, collective
Sharing (process):	none, data, ***information***, ***knowledge***
Sharing (product):	none, data, ***information***, knowledge
Coordination:	none, ***replication***, constraint, trust, voting, anarchy
Distribution:	common, ***local***, ***remote***
Diversity:	uniform, ***mixed***, ***disparate***

Figure 27 Description of Sympathetic Thought Systems using the Knowledge Systems View Schema

The dominant architectural characteristics of Sympathetic Thought Systems can be anticipated to be:

- very small group size
- high adaptability
- dynamic coordination
- very low redundancy
- rapidly (re-)configured

The Knowledge System components of Sympathetic Thought Systems will be able to think the same thoughts as each other. This contrasts with both Empathetic Thought Systems and conventional Thought Systems. The Knowledge System components of Empathetic Thought Systems will be able to know what each other is thinking; the Knowledge System components of conventional Thought Systems can (at best) only be confident that they have guessed correctly what the others are thinking.

Sympathetic Thought Systems could be expected to enable radical changes in C4ISREW, especially in respect of the structure, staffing and operation of Command Centres.

5.6 Pluralistic Thought Systems

Both Empathetic and Sympathetic Communication create the opportunity to synthesise Thought Systems whose components think about the same issues in fundamentally different ways at the same time. Although this would not always be the case, there are circumstances in which such concurrent diversity in thinking would have major advantages. Examples include:

- Campaign Planning
- Anti-War Activities

6 Implications for Defence

'There are some possessions, which are not diminished by being shared, and which, on the contrary, are not fully possessed unless they are shared.'

St Augustine

This Section discusses the Defence implications of the ideas presented earlier in the paper. It begins with a general discussion of the possible consequences of adopting an architectural approach in considering TWAW issues. It then discusses some specific instances in which the different ways of "thinking together" that have been envisaged could make an impact on Defence issues.

6.1 General

A central idea of this paper has been the suggestion that Data Systems, Information Systems, Knowledge Systems, Will Systems and Feeling Systems can be synthesised synergistically to form powerful Thought Systems. It has also suggested that the adoption of an architectural perspective of TWAW that encompasses this way of thinking gives a much broader perspective than that afforded by conventional approaches in which only Data Systems and Information Systems aspects are taken into consideration.

It is contended that various advantages accrue from this which include:

- It enables a "big picture", to be formed of TWAW in which the Knowledge Edge emerges as a dynamic, constantly changing phenomena resulting from the interaction of the allies and adversaries' Culture Systems[79]. Appendix H provides a preliminary discussion of this phenomenon.
- It helps to expose the differences between: Thought Warfare and Anti-Warfare (TWAW); Knowledge Warfare and Anti-Warfare (KWAW); and Information Warfare and Anti-Warfare (IWAW). (Baumard, [Baumard 1996], is one of the few authors who have addressed this topic in the open literature; Appendix F provides some details.) More importantly, it allows the interaction of such types of warfare to be considered. (Baumard, [Baumard 1996], and Wilensky, [Wilensky 1967], make insightful comments on this topic; Appendix F provides some details. Appendix G provides a light-hearted example that also addresses this issue.)

Further consideration within Defence of these issues is highly recommended.

6.2 Specific

There are innumerable specific instances in which the new types of Thought System proposed in Section 5 could be applied to advantage in Defence. Some of these have been

[79] Section 2 defined a Culture System as a System of Thought Systems that attempts to share thoughts by operating within a shared culture. Appendix I provides a definition and explanation of the concept of System of System.

alluded to in passing in the preceding Section. A selection from these, and some others, are discussed more fully below.

6.2.1 Knowledge Sharing Artificial Thought Systems

If Non-Natural Knowledge Systems can be developed, then it will be possible to synthesise Knowledge Sharing Artificial Thought Systems[80] that exploit (some degree of) direct knowledge sharing. If such developments can be achieved, then major advances in the architecture of Thought Systems can be anticipated that derive mainly from a reduced reliance on information sharing for communication and coordination. The performance characteristics of Knowledge Sharing Artificial Thought Systems are expected to be markedly superior to those of conventional Thought Systems.

In the Defence context, the Thought System applications that are expected to benefit most from such advances are those that are currently characterised by being both information and knowledge intensive and involve more than one human being. Examples include:

- Campaign Planning
- C4ISREW Systems
- Joint Systems

It is contended that, notwithstanding such developments, human beings will continue to be the most significant and adaptive thinking components of Thought Systems. Indeed, the Thought Systems that make the most extensive use of Non-Natural Knowledge Systems (in conducting simple thought-based tasks), will also create increased opportunity for their human components to do what they do uniquely well: adapting, innovating and learning complex thought-based tasks particularly when this involves interacting with other people.

6.2.2 Collective Thought Systems

Demographically speaking, the population of Australia has high levels of:

- Education
- Computer literacy
- Information Technology ownership
- Telecommunications technology ownership

This represents an opportunity to synthesise various types of Collective Thought System for use in Defence applications such as intelligence gathering, Information Operations, Information Warfare, surveillance, etc. Such systems would be expected to involve large-scale nationally distributed networks of military and civilian analysts.

Establishing a new arm of the Defence Reserve with responsibility for staffing and orchestrating the synthesis and operation of such Collective Thought Systems may well be an appropriate means of taking advantage of this opportunity.

[80] Section 2 provides a definition and explanation of these concepts.

Furthermore, it may be appropriate to establish a Media Operations Centre to enhance Australia's capability to conduct "Media War". The lessons learned by NATO in the Kosovo conflict are expected to be very telling in this respect, [Stourton 1999]. It may be possible to exploit Collective Thought Systems in this context.

6.2.3 Empathetic and Sympathetic Thought Systems

Even modest developments in respect of Empathetic Communication and Sympathetic Communication would enable radically different C4ISREW Systems to be devised and developed. As a consequence of the reduced dependence on information sharing of these modes of communication, fundamental improvements in Command and Control (C2) could be anticipated in respect of dependability, capacity, speed, flexibility and adaptability. Such improvements would be expected to be especially beneficial at the higher levels of Command and Control. Such benefits could accrue from:

- The ability to devise and operate radically different C2 organisational structures especially in Headquarters and Command Centres. In particular, possibilities would be created to deploy non-hierarchical C2 structures, eg network structures, that may be able to achieve performance improvements especially in terms of versatility, adaptability and robustness.
- The possibility of deploying radically different personnel profiles tailored to the needs of specific situations. For example, it would allow both military and civilian specialists to be co-opted into a Headquarters or a Command Centre, etc for a specific operation to which their expertise is germane. Possible examples include linguists, cultural experts, political analysts, etc.
- The likelihood of developing greatly improved levels of situational awareness through more direct mechanisms of developing "shared understanding". See [Briggs 1998];
- The likelihood of improvements in successful communication of intent through reduction of interpretation error rates. See [Shattuck and Woods 1999]

The development of a shared vision of the Australian way of warfighting is currently addressed by the development of a 'band of brothers' ethos, [Defence 1998]. Protracted periods of training, education and enculturation promote a largely homogenous military culture in which shared understanding is developed by talking and thinking in the same way. Developments in Empathetic Communication and Sympathetic Communication would decrease the need for such uniformity and, therefore, for such lengthy learning phases. They would also create opportunities to exploit diversity in talking and thinking; this could be highly beneficial in some circumstances.

6.2.4 Comments

This sub-section has outlined the ramifications for Defence of the development of the new forms of Thought System proposed above. Although it is appreciated that a full consideration of this issue requires a deeper understanding of how such advances could be made than is currently held, it is nevertheless possible to venture some provisional hypotheses concerning how Defence is most likely to accrue best advantage from the opportunities thus created.

In particular, it is contended that neither the development of Artificial Knowledge Systems nor the acquisition of technologies that deal with information in revolutionary ways can be anticipated to achieve the most significant advances in TWAW. It is also contended that the richest and most sustainable possibilities will be created by the development of learning strategies to foster human beings' abilities to think together in radically different ways. Furthermore, and initially this may appear counter-intuitive, it is tentatively asserted that the costs, time-scales and technical risks associated with the second contention may be less than the first. The following remarks are hazarded in this context.

- Cost of experimenting/developing with Empathetic Communication < cost of experimenting/developing with equivalent technology.
- Timescales of experimenting/developing with Empathetic Communication ~ major Defence procurement ie of the order of a human generation.

In summary, it is suggested that achieving and sustaining the edge in TWAW will derive from a culture step-change as opposed to a technology step-change.

Again, further consideration within Defence of these issues is highly recommended.

7 Way ahead

'Whatever you can do, or dream you can, begin it. Boldness has genius, power and magic in it.'
Goethe

It is recommended that a research program be initiated to investigate new forms of Defence Thought Systems. The major goals of the research would be:

- To investigate means of developing new modes of communication for application in Defence Thought Systems.
- To conduct research and development in the architecture of Defence Thought Systems that exploit existing and new modes of communication.
- To investigate the new modes of cognition and consciousness that emerge from such Defence Thought Systems and exploit them in Thought Warfare and Anti-Warfare.

It is highly desirable that such a program be part of a larger Defence initiative to research the nature and conduct of Thought Warfare and Anti-Warfare.

7.1 Approach

There is a "spectrum" of different approaches that could be adopted in undertaking the program. The recommended approach to be adopted has the following main features:

- It would be a progressive, goal-driven investigation. Bumper sticker: "Think big; start small".
- It would be a fundamentally multi-disciplinary, team based investigation. Team members needed include: multi-disciplinary thinkers, architects, cognitive scientists, educationalists, psychologists, anthropologists, cyberneticists, military training experts, computer scientists, etc.
- In the initial phases at least, three streams of investigation would be conducted to address three broad categories of Knowledge Systems, namely: Non-Natural; Hybrid; and Human.

7.2 Strategy

There is a "spectrum" of different strategies that could be adopted in initiating and managing the program. The recommended strategy to be adopted has the following main features:

- Establish whether it is deemed appropriate for DSTO to be involved in research of this type. If DSTO does not wish to either lead or participate in such research, then establish whether there are other arrangements under which it could progress.
- Seek high-level commitment for the program.
- Identify an appropriate leader for the program.
- Investigate whether similar or related work is being conducted elsewhere.

- Establish whether collaboration is a viable with existing workers in related fields.
- Establish the core of a multi-disciplinary team. Strive to keep the team core as stable as possible throughout the program.
- Deploy other team members on an "as needed" basis as the investigation progresses.

7.2.1 Non-Natural

Investigate the feasibility of creating Non-Natural Knowledge Systems using current and foreseeable technologies. Candidate technologies include:

- Artificial Intelligence
- Intelligent agents

7.2.2 Hybrid

Investigate the feasibility of creating Hybrid Knowledge Systems using current and foreseeable technologies. This could be anticipated to involve:

- Investigating the state-of-the-art in relevant bio-engineering initiatives. For example, it would be worth investigating the work being done on "empathy chips" by the Department of Cybernetics, University of Reading, UK.
- Speculating on the future of bio-engineering developments eg KnowledgeWeb, [Burke 1998], ThoughtShare, [Burke 1998], MindShare, [Burke 1998], "spiritual machines", [Kurzweil 1999], etc.
- Speculating on the future of genetic-engineering developments.

7.2.3 Human

Investigate the feasibility of creating new forms of Human Knowledge Systems using current and foreseeable technologies. This could be anticipated to involve:

- Investigating the state-of-the-art in relevant learning initiatives. Leads worthy of further investigation include:
    - Derek Bopping's ANU based PhD work on Social Cognition is known to be of direct relevance to the proposed research. Other members of Derek's department may have interests in this area.
    - It is possible that the Institute for Research on Learning (IRL) may be involved in issues relating to Empathy Communication etc.
    - The work on Social Learning initiated by John O'Neill and now led by Leoni Warne may have some relevance. John's current work in NASA may also be relevant.
- Accepting that we need to "learn how to learn" how to "think together" and that early investigative activities will be highly exploratory and provisional.
- Accepting that "learning how to learn" will need to precede "learning how to teach" how to "think together".
- Being open to the possibility that teaching how to "think together" may not be the best way for people to acquire such capacities.

- Trying to identify situations where such adaptations have already occurred and investigate appropriately. For example, some useful pointers in this respect may be provided by investigating:
    - "special" schools set up for children with unusual gifts, needs, disabilities, etc. Examples include: international multi-lingual schools populated by the children of diplomats, politicians etc; music schools; blind schools; deaf schools
    - twins, triplets etc, particularly those with sight/hearing difficulties
    - (silent) orders of monks/nuns
    - very established couples who "speak for one another"
    - very close families
- Conducting a review of what is known about non-mainstream areas such as telepathy, Extra Sensory Perception, etc. For example, US DOD[81] has conducted serious studies of such activities in the past and their results could be relevant.
- Establishing "learning environments" in which people are encouraged to acquire the ability to "think together" by exposing them to situations in which such capacities are beneficial. For example, various sorts of games, activities etc in which small groups of people need to cooperate in doing different sorts of thought-based tasks in order to prosper. Investigate the consequences of progressively reducing the information richness of the environments and observe whether any adaptations occur. Compare with current "learning environments" that tend to emphasise learning of individual based thought-based skills on a competitive basis in information rich settings.
- Introducing people to such learning programs at times in their lives when they are most adaptive and before they have been enculturated in ways that mitigate against such adaptation taking place ie when they are very young.
- Devising military training schemes aimed at promoting the development of "thinking together" abilities in cadets selected as candidates for future Command Centre positions. Some nations, [Fuss 1999], select future commanders in their teenage years for subsequent specialised training and development. Note that it would not be appropriate for all cadets to be exposed to such training.
- Devising selection schemes for entry into such training programs. Selection criteria may include empathy/cooperation characteristics. Assessment may take place at very young ages and in the context of appropriate "learning environments". Compare to current practice in Australia and overseas. Examples include:
    - Selecting young athletes for specialised training for future high-level competition based upon their behaviour in physiological tests. For example: AIS rowing, AIS cycling etc.
    - Selecting young musicians for specialised education in "schools for the gifted". For example: Yehudi Menuhin School, etc.

7.3 Comments

If any further initiative were to be taken in respect of the proposed program, then it may be appropriate for some aspects of it to be made subject to security restrictions.

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[81] See, for example, Shacknow, [Shachnow 1992] for a discussion of such possibilities.

8 Discussion

'It is a mistake to believe that acquiring revolutionary technologies in itself constitutes a revolution in military affairs.'

Paul Dibb, [Dibb 1997]

This paper has attempted to paint on a broad canvas using bold strokes and a deliberately simple technique; it provides perspective by suppressing detail. It gives an impression of an emerging and rapidly changing subject that allows the major features to be distinguished and the nature of the change to be appreciated. Clearly, this approach is not suitable for all purposes. Furthermore, and particularly in view of the clumsiness of its execution, it cannot be expected to appeal to all tastes. The following discussion tries to make a balanced appraisal of the significance of what has been presented.

The paper has originated the concept of Thought Warfare and Anti-Warfare (TWAW) as a generalisation of the concept of Knowledge Warfare and Anti-Warfare (KWAW) discussed by the Tofflers, [Toffler and Toffler 1993], and others. It has argued that major comparative advantage in TWAW can be anticipated if new types of Thought Systems can be realised; various proposals have been made in this respect. A research program to investigate Defence applications of such Thought Systems has been outlined.

It has suggested that such Thought Systems have the potential to make important contributions to a Revolution in Military Affairs (RMA), [ORMA 1999]. It is noted that such contributions would constitute step-changes in the capabilities of Knowledge Systems, C(KS), rather than in the capabilities of Information and Data Systems, C(IS) and C(DS) respectively. Furthermore, since Dibb, [Dibb 1997], has argued that systems integration and cultural change are key issues concerning RMA in the Asian Security context, it is abduced that such changes would have strategic significance in this respect.

It is suggested that as a multi-cultural nation that embraces diversity, Australia has the potential to be able to develop a sustainable advantage in C(KS), relative to its likely adversaries, that can be exploited in TWAW. Realising this potential will, however, require bold initiatives to be taken in exploring and adopting novel learning strategies. Although it may be appropriate to restrict such initiatives to Defence, circumstances can be imagined in which the involvement of people from the community at large may be appropriate. Examples include:

- Collective Intelligence: Use of large-scale, nationally distributed networks of civilian analysts in surveillance, cyber operations etc.
- Defence Reserve: Creation of a new arm of the Defence Reserve to populate and orchestrate such systems.
- Empathetic Cognition: Co-opting of civilians with specialist skills in Command Centres for specific operations. Possible examples include linguists, cultural experts, political analysts, etc.

Although the Defence implications of Feeling Systems and Will Systems have not been discussed in any depth, it would seem possible that these too may be used advantageously in TWAW. Accordingly, it is recommended that the scope of any future research into Thought Systems should be extended to include consideration of these issues.

It is suggested that if the current trend in Australian society of "not having the will to fight (sustained) wars", [Fairs 1999], continues then there will be an increasing socio-political imperative on Defence to address the demands of Anti-War. If this were the case, then the foreshadowed advances in Thought Systems could play a significant role in Defence's response to this imperative and contribute to a genuine Revolution in Military Affairs.

The ideas and arguments presented in the paper have been couched, almost entirely, within the "Architecture Thinking" paradigm, [Burke 2000][82]. Although the scope of this paradigm is theoretically adequate to address the full scope of the TWAW domain, it is contended that it is not sufficient by itself to comprehensively cover all aspects of what is concerned. In future work, careful consideration needs to be made of how this paradigm should be augmented to develop richer conceptions of the domain. Input from the theory of Multi-Disciplinary Thinking is anticipated to have great value in this respect; Kline's work, [Kline 1995], is considered to be particularly relevant.

For a combination of logistical and presentational reasons, the paper has made use of only the simplest of architectural techniques. In particular, only a crude Knowledge Systems View schema has been used in describing Thought Systems. It is acknowledged that the basis of the schema is not well considered and, furthermore, that that the use of any single Architecture View cannot give a comprehensive description of non-trivial Thought Systems. Despite the distortion inherent to such compromises, it was considered adequate, in such an introductory paper, to limit such descriptions in this way. It is highly recommended that any further work in this domain make use of better-founded methods than those used in this preliminary exposition. Full consideration of this matter is expected to require inputs from various disciplines notably cognitive science and architecture.

Notwithstanding the preceding comment, the Knowledge Systems View schema does indicate how architecture descriptions of systems can be made from the knowledge perspective. This early work on "knowledge architectures"[83], casts some faint light on how existing Architecture Description Frameworks[84] such as the C4ISR Architecture Framework, [C4ISRAWG 1997], originally developed to describe just Information Systems, could be augmented to support description of Knowledge Systems. There is an increasing awareness in Defence communities of the need for such developments; a paper currently being prepared by Cook et al., [Cook, Kasser et al. 2000], strives to clarify this.

[82] It is interesting to compare the "architecture thinking" paradigm with Checkland's "systems thinking" paradigm, [Checkland 1981; Checkland 1990; Checkland and Holwell 1998].

[83] *Understanding Architecture*, [Burke 2000], argues that the term "knowledge architecture" is a confusing term for the concept that it refers to.

[84] *Understanding Architecture*, [Burke 2000], provides a definition and explanation of this concept.

9 Concluding Remarks

'Fools act on imagination without knowledge and pedants handle knowledge without imagination.'
Alfred North Whitehead

This paper is an unashamed speculation about the nature of future TWAW: an act of imagination based on very little knowledge. As such, it may well be both foolish and foolhardy. But is this important? Pedantically speaking, if the paper creates any new knowledge, then surely the outstanding issue to be addressed is whether that knowledge can be handled with sufficient imagination for it to contribute to a Revolution in Military Affairs?

Will we ever know; or can we only imagine?

10 Acknowledgements

Various people have made contributions to this work. All of them are appreciated and are acknowledged with gratitude.

The following people contributed by providing interaction and feedback:

- Mike Jarvis of the Capability Analysis Staff, ADHQ;
- Balaram Das of Systems Simulation Assessment Group;
- Neil Bryans (Chief, Information Technology Division);
- Jennie Clothier (Research Leader, Joint Systems Branch);
- Professor Stephen Cook and David Harris of the Systems Engineering and Evaluation Centre, University of South Australia;
- Ian Fuss (Research Leader, Command and Control and Intelligence Branch);
- Jason Scholz (Research Leader, Military Computing Systems Branch);
- Richard Hodge (Scientific Advisor, Strategic Policy and Plans);
- John Hansen of Human Systems Integration Group;
- Derek Bopping, Greg Calbert, David Matthews, Gina Kingston and Moira Chin of Joint Systems Branch;
- Tony Cant of Trusted Computer Systems Group;
- Alex Yates, Justin Fidock and Simon Utteridge of C3I Operational Analysis Group;
- Greg Marsh of C2 Australian Theatre Group;
- Ian Turner of Software Systems Engineering Group;
- Marion Andrew of the Women's and Children's Hospital, Adelaide.

Stephen Fry of Software Systems Engineering Group made a specific contribution by realising the diagrams used in the paper. Kaye Trottman of Information Technology Division also made a specific contribution by assisting in the publication of the paper.

It is emphasised that the involvement of these people in this work should not necessarily be taken as an indication that they endorse or indeed agree with the views that it develops.

11 References

ABS (1999). ABS Pub. No. 8147.0: Use of the Internet by Householders, Australian Bureau of Statistics.

Alberts, D. S., J. J. Garstka, et al. (1999). Network Centric Warfare: Developing and Leveraging Information Superiority, C4ISR Cooperative Research Program, US DOD.

Authier, M. and P. Levy (1992). Les Arbres de connaissances. Paris, La Decouverte.

Ayer, A. J. (1967 (1946)). Language, Truth and Logic. London, Victor Gollancz.

Barrett, R. A. (1991). Culture and Conduct: An Excursion in Anthropology. Belmont, California, Wadsworth Publishing Company.

Barthes, R. (1964). Elements of Semiology. New York, Hill and Wang.

Baumard, P. (1996). From InfoWar to Knowledge Warfare: Preparing for the Paradigm Shift. Intelligence Newsletter.

Berlin, I. (1979). Against the Current: Essays in the History of Ideas. London, Pimlico.

Berlin, I., Ed. (1990). The Crooked Timber of Humanity: Chapters in the History of Ideas, Fontana.

Blockley, D. (1980). The Nature of Structural Design and Safety, Ellis Horwood.

Bonabeau, E., M. Dorigo, et al. (1999). Swarm Intelligence: From Natural to Artificial Systems. New York, Oxford University Press.

Boulding, K. (1956). "General Systems Theory: The Skeleton of Science." Management Science **2**(3).

Boulding, K. E. (1956). The Image: Knowledge in Life and Society, University of Michigan Press.

Brabin-Smith, R. (1999). CDS Roadshow April - May 1999.

Brehmer, B. (1997). The Way Ahead: Research Tasks in ROLF 2. Better Design Techniques workshop, DSTO C3 Research Centre, Canberra, Australia.

Briggs, P. (1998). Opening Remarks - The Challenges and Objectives. Situational Awareness Symposium, DSTO, Salisbury.

Broad, C. D. (1923). The Mind and its Place in Nature. London, Kegan Paul.

Trench and Trubner (Reissue 1980).

Burke, M. M. (1991). Software Dependability Assessment. Department of Engineering Mathematics. Bristol, UK, University of Bristol.

Burke, M. M. (1998). A Knowledge Space for Defence. (Unpublished. Available from the author on request.), DSTO Working Note.

Burke, M. M. (1998). Knowledge Web for EXC3ITE: Outline Proposal. (Unpublished. Available from the author on request.), DSTO Working Note.

Burke, M. M. (1999). Socio-Epistemo-Technical Systems: A Polemic. Systems Engineering Test and Evaluation Conference (SETE99), Adelaide, South Australia. (Unpublished. Available from the author on request.).

Burke, M. M. (2000). Understanding Architecture, Draft DSTO Research Report. (Available from the author on request.).

Burke, M. M. and M. Jarvis (1999). On antonyms for synergy. (Personal communication).

Burns, D. (2000). DIE Strategic Plan (In preparation), C4ISREW Staff.

C4ISRAWG (1997). C4ISR Architecture Framework v2.0.

Capra, F. (1996). The Web of Life: A New Synthesis of Life and Matter, Flamingo.

Chatfield, C. (1983). Statistics for Technology: A Course in Applied Statistics, Chapman and Hall.

Checkland, P. (1981). Systems Thinking, Systems Practice. Chichester, Wiley.

Checkland, P. (1990). Soft Systems Methodology in Action, Wiley.

Checkland, P. and S. Holwell (1998). Information, systems and information systems: making sense of the field. Chichester, Wiley.

Chessell, C. I. (1997). Program Takari - C3I of the Future. Society of Military Engineering - Second National Conference, 'Science and Industry, Partners assisting the Services in the Defence of Australia', DSTO, Salisbury, Adelaide.

Chin, M. (1999). DIEWG Paper No. 2: The Defence Information Environment, DSTO.

Condon, W. S. (1976). "An Analysis of Behavioural Organisaton." Sign Language Studies **13**.

Cook, S. C., J. E. Kasser, et al. (2000). Assessing the C4ISR Architecture Framework for the Military Enterprise. 5th International Command and Control Research and Technology Symposium, (ICCRTS2000), Australia War Memorial, Canberra, ACT, Australia. (In preparation).

Davenport, T. H. and L. Prusak (1997). Information Ecology, Mastering the Information and Knowledge Environment. New York, Oxford University Press.

Defence (1997). Australia's Strategic Policy (ASP97), Department of Defence, Canberra, Australia.

Defence (1998). Decisive Manoeuvre: Australian Warfighting Concepts to Guide Campaign Planning, Interim Edition, Department of Defence, Headquarters, Australian Theatre.

DeMillo, R. A., R. J. Lipton, et al. (1979 May). "Social Processes and Proofs of Theorems." Communciations of ACM **22**(5).

Derrida, J. (1978 (1967)). Writing and Difference. London, Routledge & Kegan Paul.

Descartes, R. (1986 (1637 and 1641)). Discourse on Method and the Mediations. Hammondsworth, Penguin.

DFW (1999). Project Sphinx: Future Warfare Concepts Draft Summaries Index, Directorate of Future Warfare, ADHQ.

Dibb, P. (1997). The Revolution in Military Affairs and Asian Security. IISS Annual Conference on Security Challenges in the Rising Asia-Pacific, Singapore.

DOD (1997). Joint Vision 2010. America's Military: Preparing for Tomorrow. Washington, DC 20318-5126, Chairman of the Joint Chiefs of Staffs, 5216 Joint Staff, Pentagon.

Edgar, A. and P. Sedgwick, Eds. (1999). Key Concepts in Cultural Theory. Key Concepts Series. London and New York, Routledge.

Fairs, K. (1999). Survey of Key Issues in the Defence of Australia. (Personal communication).

Flood, R. L. and M. C. Jackson (1991). Creative Problem Solving, John Wiley & Sons.

Foucault, M. (1980). Power/Knowledge. Brighton, Harvester.

Fuss, I. (1999). Selection and Training of Future Commanders. (Personal communication.).

Gay, P. d., Ed. (1997). Production of Culture/Cultures of Production, Sage Publications Limited.

Gell-Mann, M. (1994). The Quark and the Jaguar: Adventures in the Simple and the Complex, Abacus.

Goodyer, M. (1999). Introductory Remarks. First Krait Wargames, Canberra, Australia.

Hall, S., Ed. (1997). Representation: Cultural Representations and Signifying Practices, Sage Publications.

Hume, D. (1990 (1739)). A Treatise on Human Nature. Oxford, Clarendon Press.

Jarvis, M. W. (1999). Organisation, Knowledge and Change: Defence as a Learning, Adaptive, Innovative Organization, Capability Analysis Staff, ADHQ.

Jordan, B. (1993). Birth in Four Cultures : A Crosscultural Investigation of Childbirth in Yucatan, Holland, Sweden, and the United States, Waveland Press.

Kant, I. (1964 (1781)). Critique of Pure Reason. London, Macmillan.

Kline, S. J. (1995). Conceptual Foundations for Multidisciplinary Thinking. Stanford, California, Stanford University Press.

Krogh, G. v. and J. Roos (1995). Organisational Epistemology, Macmillan Press (UK), St Martin's Press (USA).

Kuhn, T. S. (1996 (1962)). The Structure of Scientific Revolutions. Chicago, University of Chicago Press.

Kurzweil, R. (1999). The Age of Spiritual Machines: When computers exceed human intelligence., Alllen & Unwin.

Lakoff, G. and M. Johnson (1980). Metaphors We Live By. Chicago, University of Chicago Press.

Levy, P. (1997). Collective Intelligence: Mankind's Emerging World in Cyberspace. New York, USA, Plenum Press.

Meyer, M. (1998). Situational Awareness. Situational Awareness Symposium, DSTO, Salisbury.

Neitzsche, F. W. (1986 (1878 - 80)). Human, All-Too Human. Cambridge, Cambridge University Press.

Nonaka, I. and N. Konno (1998 (Spring)). "The Concept of "*Ba*": Building a Foundation for Knowledge Creation." California Management Review **40**: 40 - 54.

Nonaka, I. and H. Takeuchi (1995). The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. New York, Oxford University Press.

ORMA (1999). The 'Revolution in Military Affairs' and the Australian Defence Force: A Public Discussion Paper, Office of the Revolution in Military Affairs.

Plato and N. Fowler (1987). Plato, Vol. III Theaetetus Sophist. Cambridge, Mass, USA, Harvard University Press.

Polanyi, M. (1958). Personal Knowledge: Towards a Post Critical Philosophy. Chicago, Illinois, University of Chicago Press.

Polanyi, M. (1966). The Tacit Dimension. London, Routledge & Kegan Paul.

Popper, K. (1977). The Logic of Scientific Discovery. London, Hutchinson.

Popper, K. R. (1994). The Philosophy of History. The Myth of the Framework: In Defence of Science and Rationality. M. A. Notturno. London, Routledge and Kegan Paul.

Ronfeldt, D., J. Arquilla, et al. (1998). The Zapatista Social Netwar in Mexico, RAND, Arroyo Center.

Saussure, F. d. (1983 (1916)). Course in General Linguistics. C. Bally and A. Sechehaye. London, Duckworth.

Shachnow, S. (1992). Schachnow Technology Timeline. John F Kennedy Special Warfare Course and School, Fort Bragg, N.C., USA.

Shakespeare, W. (1994). King Henry the Fifth. William Shakespeare: The Complete Works. ShakespeareHeadPressOxford. New York, Barnes and Noble Books.

Shattuck, L. G. and D. D. Woods (1999). Communication of Intent In Military Command and Control Systems. The Human in Command: Exploring issues in military social science. C. McCann and R. Pigeau, Plenum Press.

Sowa, J. F. (1984). Conceptual Structures: Information Processing in Mind and Machine, Addison Wesley.

Stourton, E. (1999). Spinning for Victory, Electronic Telegraph. **1999.**

Sveiby, K. E. (1998). Tacit Knowledge, Sveiby Knowledge Management http://www.sveiby.com.au/Polanyi.html.

Sveiby, K. E. (1998). What is Knowledge Management?, Sveiby Knowledge Management http://www.sveiby.com.au/KnowledgeManagement.html.

Sykes, J. B., Ed. (1977). The Concise Oxford Dictionary of Current English, Oxford University Press.

Takari (2000). Takari Program Intranet Site, Jane Babbidge. **2000.**

Thompson, K., Ed. (1997). Media and Cultural Regulation, Sage Publications Limited.

Toffler, A. (1990). Powershift: Knowledge, Wealth and Violence at the Edge of the 21st Century. New York, Bantam Books.

Toffler, A. and H. Toffler (1993). War and Anti-War: Survival at the Dawn of the 21st Century, Little, Brown and Company.

Toohey, P. (1999). All dressed up, only one place to go. The Australian: 1, 16 September 1999.

Vencel, L. (2000). C4ISREW database for the ADF. (Personal communication).

Wartofsky, M. W. (1968). Conceptual Foundations of Scientific Thought. New York, Macmillan.

Wenger, E. (1990). Toward a theory of Cultural Transparency: Elements of a Social Discourse of the Visible and the Invisible. Department of Information and Computer Science, University of California at Irvine.

Wenger, E. (1998). Communities of Practice: learning, meaning and identity. New York, Cambridge University Press.

Wilensky, H. (1967). Organisational Intelligence. The International Encyclopedia of the Social Sciences. D. L. Sills. New York, Macmillan and The Free Press. **11.**

Wittgenstein, L. (1958). The Blue and the Brown Books. London, UK, Blackwell.

Wittgenstein, L. (1961 (1921)). Tractatus-Logico-Philosophicus. London, Routledge & Kegan Paul.

Wittgenstein, L. (1967 (1953)). Philosophical Investigations, Blackwell Publishers.

Yu-Lan, F. (1948). A Short History of Chinese Philosophy, The Free Press.

Appendix A: Objective and Subjective Knowledge

'There are no facts, only interpretations.'

Friedrich Nietzsche

Although circumstances exist in which knowledge is treated as if objective, it is contended that knowledge is inherently subjective. In some instances, the derivation of objective knowledge from subjective knowledge may be approached, in some asymptotic sense, through a process of consensus. However, since all processes of consensus are essentially social in nature, absolute objective knowledge can never be achieved.

This is the case even in rigorous, abstract disciplines such as pure mathematics. In mathematics, knowledge is encapsulated in axioms and theorems. Axioms are fundamental, incontrovertible statements from which other statements, ie theorems, can be deduced using formal reasoning systems. The deduction of theorems in this way is referred to as the process of mathematical proof. It is perhaps rarely appreciated that the acceptance of a mathematical proof takes place by a social process. This process involves the theorem under consideration being offered to other members of the mathematical community for their scrutiny. If these assessors can detect no errors in the reasoning then the theorem is provisionally accepted as being valid. The level of support that is given to the validity of the proof depends upon the severity, diversity and extent of the attempts made to find inadequacies in the reasoning of the proof. De Millo, Lipton and Perlis discuss this issue in some depth, [DeMillo, Lipton et al. 1979 May].

Appendix B: Empathetic Communication

'For a deaf, dumb and blind kid,
He sure plays a mean pin-ball.'

Pin-Ball Wizard
The Who

Empathetic Communication is a tacit means of sharing information. A person capable of Empathetic Communication will have a (heightened) intuitive power/faculty that enables them to be aware of what other people are doing and thinking without the need for large amounts of (explicit) information to be transferred.

The type of information involved in Empathetic Communication is different to that used in conventional Thought Systems. For example, it could take the form of subtle, non-articulated cues.

It is anticipated that the human mind's capacity for adaptation could be exploited to deliberately develop such faculties.

Considerable evidence exists to suggest that (some) human minds are sufficiently adaptable to be able to learn how to deal successfully in information-sparse environments. For example, visually impaired individuals can develop abilities to conduct complex, spatio-temporal activities requiring high levels of "hand-eye" coordination considered challenging by many normally sighted people[85].
Arguably, this comes about through the visually impaired individuals learning "action strategies" that function adequately with the very low quality visual information that they have to deal with. Such adaptation is much more likely to occur successfully in very young children than in older people. (For example, people who are born blind or partially sighted typically accommodate much more successfully to the demands of their handicap than those who develop similar conditions in later life.)

Evidence also exists to suggest that some human beings are capable of sensing what others are doing or thinking with minimum information exchange. For example, twins often develop the ability to "know one another's minds" with high degrees of confidence. Arguably, this comes about through a combination of genetic factors and protracted periods of being/learning together in their infancy and childhood.

Key factors that can be anticipated to have a bearing on any attempts to deliberately develop people capable of Empathetic Communication include:

[85] As someone who was partially sighted until his early twenties, the author can attest to this from personal experience.

- A considerable range in (natural) aptitude for Empathetic Communication can be expected. This suggests that candidates for training programs should be carefully selected. Careful consideration of appropriate assessment processes, selection criteria etc. would be needed.
- Specificity/generality of Empathetic Communication on the basis of:
    - Task (type)
    - Group (type)
    - Individual (type)
    - Information (type)
    - Information (sparsity)
- The intensity of the learning program involved in developing Empathetic Communication skills. This would involve the following factors as well as those listed above :
    - Age of the trainees
    - Training period
    - Diversity of the communication/cognitive tasks involved
    - Dependence/need to adapt
    - Availability of other means of communication
    - Rates of change of information-sparsity of the communication/cognitive tasks involved
- The faculties necessary for Empathetic Communication are not usually explicitly encouraged in science, engineering and military communities.

It would be interesting to compare the ideas behind Empathetic Communication with those of other researchers in related areas. For example, the author is aware that Condon's work on "entrainment" or "synchronising behaviour", [Condon 1976], would be worth investigating further in this respect. It is considered that it would be very worthwhile to conduct a thorough literature review to establish other relevant sources.

A full discussion of the inter-relationship of such ideas would require a separate paper and may even be an appropriate topic for a Masters/PhD thesis in a discipline such as Psychology.

Appendix C: Sympathetic Communication

Sympathetic Communication is an explicit means of sharing information and/or knowledge processes. A person capable of Sympathetic Communication will have a capacity to be aware of what other people are thinking without the need for (explicit) information transfer.

It is anticipated that Sympathetic Communication will be enabled by either:

- Bio-engineered devices that enable direct information/knowledge sharing by humans. The so-called "empathy chip" may provide a primitive example of such a device.

Appendix D: Occidental Epistemologies[86]

Appendix D summarises the views of some prominent Occidental[87] thinkers regarding the nature of knowledge. For the purpose of this paper, these have been grouped under three loose headings. The first of these is the conception of knowledge due to Socrates/Plato that is considered to have acted as a general backcloth for Occidental thinking over the intervening two and a half millennia since it was first professed. The second is the conception of knowledge as a product or commodity that has, perhaps, also prevailed in this period. The third is the conception of knowledge as a process of knowing which has emerged in the second half of the twentieth century.

It will be noted that there is considerable diversity between the views; indeed some of them appear diametrically opposed. However, before going any further in this, it would, perhaps, be wise to bear in mind Wittgenstein's thoughts on the topic. He held that "knowledge" is not easily defined in an exact manner, [Wittgenstein 1958], and stated that:

'There is no exact usage of the word knowledge; but we can make up several such usages, which will more or less agree with the ways the word is actually used.'

D.1 General

Studies of knowledge in Occidental cultures have always been characterised by problems with definitions. Plato's account of Socrates' dialogue with the mathematician Theaetetus, was largely concerned with this, [Plato and Fowler 1987]. After distinguishing between knowledge and the application of knowledge, the dialogue centres on knowledge as:

a) sensible perception;
b) true opinion;
c) true opinion with reasoned explanations.

Authors differ in their interpretations of the outcome of this debate. For example, von Krogh and Roos, [Krogh and Roos 1995], suggest that no definition emerged which could not be refuted. Whereas, *Encyclopaedia Britannica* states: "in *Theaetetus* Plato concludes that knowledge is justified true belief"; that is that he accepted the third of the above definitions.

There can be little doubt, however, that the conception that knowledge is "**justified true belief**", irrespective of whether it is valid or not, has formed the basis of mainstream Occidental philosophy's understanding of "What is knowledge?". This is explained by Nonaka and Takeuchi, [Nonaka and Takeuchi 1995], in the following way:

[86] Epistemology is the theory of knowledge. It is one of the main branches of philosophy; its subject matter concerns the nature, origin, scope and limits of human knowledge.
[87] It is worth bearing in mind that in other cultural traditions such issues can be the understood in profoundly different ways. Differences of this nature can become crucial concerns in TWAW in which the adversaries do not share the same cultural background.

'In traditional epistemological accounts, knowledge must satisfy the following conditions. In order for Individual A to have knowledge of something (that is, a proposition, hereafter P), the following are necessary and sufficient conditions of A's knowledge of P:

*P is true (**the truth condition**);*
*A must believe that P is true (**the belief condition**); and*
*A's belief that P is true must be justified (**the justification condition**).*

According to the first truth condition, an individual's knowledge of something does not exist unless its proposition is true. Therefore, a statement like "I know P, but P is not true" is simply self-contradictory. A true proposition describes reality, which is true in the past, present, and the future.

The belief condition requires not only that a statement must be true, but also that we must believe that the statement is true. While the truth condition is an objective requirement, the belief condition is a subjective requirement. Therefore, when we claim the knowledge of P, we must assume a certain attitude toward P. Assuming an attitude toward P means we believe in P. Nevertheless, believing P is not a defining characteristic of P's being true. It is possible to say that "I believe in P, but P is not true", yet the proposition "I know P is true, but I do not believe P is true" is a self-contradiction. In short, knowledge contains belief, but belief does not contain knowledge.

The justification condition calls for evidence for proving the truthfulness of knowledge. Belief, which reveals an attitude toward P, does not justify P itself; it needs evidence of truth. Belief formed without valid evidence does not constitute knowledge, even though it could happen to be true in some circumstances.

The famous "Gettier counter-examples" provide a good case in point. Suppose one holds a belief grounded in valid assumptions. Despite the fact that the belief could be wrong in reality, it could give birth to another belief that is true. Based upon this observation, Gettier noted that a wrong belief that satisfies the above three conditions cannot produce knowledge. This is an important criticism of the imperfect nature of the mainstream conception of knowledge.'

D.2 Product: "Commodity"

Davenport, [Davenport and Prusak 1997], explains the nature of knowledge in the following manner.

'Knowledge is information with the most value and is consequently the hardest form to manage. It is valuable precisely because somebody has given the information context, meaning, a particular interpretation; somebody has reflected on the knowledge, added their own wisdom to it, and considered its larger implications. For my purposes, the term also implies synthesis of multiple sources of information over time. Some knowledge, as Ikujiro Nonaka has long noted, is tacit - it exists symbolically in the human mind and can be made explicit only with difficulty, [Nonaka and Takeuchi 1995]. Knowledge can be embedded in machines, but it's tough to categorise and retrieve effectively. Anyone who has ever tried to transfer knowledge from one

person or group to another knows how hard that is; not only must receivers use the information, but they must also acknowledge that it actually constitutes "knowledge."'

Popper,[Popper 1994], held the following opinion.

For me, knowledge consists essentially of exosomatic artefacts, or products, or institutions. (It is their exosomatic character that makes them rationally criticisable.) There is knowledge without a knowing subject - that knowledge , for example, which is stored in libraries. Thus there can be growth of knowledge without any growth of awareness in the knower. The growth of knowledge can even form the main plot of our history. And yet there may be no corresponding increase in either our subjective knowledge or our abilities. There may even be no change in our interests. Human knowledge may grow outside of human beings.'

D.3 Process: "Knowing"

Polanyi, [Polanyi 1958; Polanyi 1966], describes the nature of knowledge in the following manner.

'Knowledge is an activity which would be better described as a process of knowing'

Polanyi's views have strongly influenced the thinking of Karl Erik Sveiby, [Sveiby 1998; Sveiby 1998], who is sometimes referred to as "the father of Knowledge Management". Sveiby's work is currently having a significant impact on various initiatives in Defence concerned in which "knowledge" features.

It is interesting to note that Kenneth Boulding, [Boulding 1956], in his seminal work 'The Image[88]: Knowledge in Life and Society', defines knowledge as:

"what somebody or something knows, and that without a knower, knowledge is an absurdity"

In their book, *Metaphors We Live By*, Lakoff and Johnson, [Lakoff and Johnson 1980], propose that:

'{metaphor is} a matter of central concern, perhaps the key to giving an adequate account of understanding.'

They found it necessary to revise:

'central assumptions in the Western philosophical tradition. In particular, this meant rejecting the possibility of any objective or absolute truth and a host of related assumptions. It also meant supplying an alternative account in which human experience and understanding, rather than objective truth, played the central role. In the process, we have worked out elements of an experientialist approach, not only to issues of language, truth, and understanding but to questions about meaningfulness of our everyday experience.'

[88] Boulding defines the concept of *image* as the "subjective knowledge structure of an individual or organisation."

Appendix E: Architecture Views

Architecture Views are classes of architecture descriptions that allow knowledge about systems to be represented from particular perspectives.

E.1 Structural View

Arguably, the most common type of architecture view is the structural view[89] in which a system is depicted as a set of inter-related elements.[90] [91] Examples include:

- the contents lists of books and papers;
- the taxonomies used by biologists to categorise forms of life;
- the high-level designs of software systems;
- the schematic diagrams used by chemists and physicists to depict the configuration of atoms in crystals, molecules, polymers, etc;
- the graphs used by mathematicians to depict systems as networks of nodes and inter-connecting arcs;
- the blue-prints used by the architects of buildings and engineers in general;
- the master-plans used by military and business strategists to depict the inter-relationships of other subsidiary plans;
- the organisation charts used to depict the authority/responsibility structures in institutions;
- the family-trees used to depict the genealogy of family groups;
- the route-planners provided in road-atlases to depict the various major routes between towns, cities etc.

E.2 Piecewise View

Another common architecture view is the piecewise view that depicts the smallest relevant parts of a system for a particular problem. Examples include:

- the detailed wiring diagrams produced by electronic and electrical engineers that show the smallest components of the devices with which they are concerned and the way that they are inter-connected;
- the detailed design drawings produced by mechanical engineers that show the smallest components of the devices with which they are concerned and the way that they are inter-connected;
- the musical scores used by composers to depict the notes to be played by the instruments in orchestras;
- the ingredients lists of recipes;

[89] Kline, [Kline 1995], uses the term "structural view" to denote a description of how the components of a system "go together" for all levels of its (hierarchical) structure.
[90] IEEE Std 610.12-1990 defines the concept of architecture as follows:
architecture. The organisational structure of a system or component. *See also:* **component; module; subprogram; routine.**
[91] See Section 4.5 of *Understanding Architecture* for a discussion of the consequences to the Systems Thinking community of this definition.

- the inventories of repositories.

E.3 Synoptic View

A less common type of architecture view is the synoptic view[92]. Synoptic views treat systems as atomic entities or wholes. They selectively emphasise characteristics of the system that are deemed to be salient in a given context and suppress (or omit) information that is not pertinent in these respects. [93] Examples include:

- the synoptic weather charts used in television and newspaper weather reports. These are perhaps the examples of synoptic views that are most commonly encountered in everyday life;
- "black-box" system diagrams that emphasise the inputs and outputs to a system (the black-box) and the relationships between the inputs and outputs resulting from the action of that system. Such diagrams do not depict how the transformation from input to output takes place;
- topographical, political, climatic, demographic etc. maps;
- the High Level Operations Concept Graphics used in the C4ISR Architecture Framework[94].

E.4 Panoptic View

The panoptic view is an important but uncommon architecture view. A panoptic view of a system depicts all aspects of that system at once. In most cases, practical considerations necessitate that panoptic views only include information about systems above a given scale of resolution. An appreciation of the difference between the synoptic and panoptic views is afforded by considering the simple example discussed in Section 4.7 of *Understanding Architecture*.

Architecture descriptions that depict temporal aspects of knowledge about a system are rare.[95] The usual situation is that an architecture description depicts aspects of knowledge about a system as it exists, or is intended to be, at a single point in time. Such architecture descriptions do not capture how a system operates or changes over time. They are analogous to "snapshots" taken with a camera using a polarised filter. They are partial images of an object produced by selectively recording part of what is known about that object at a particular instant. [96]

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[92] Kline, [Kline 1995], uses the term "synoptic view" to denote a synthetic overview of a system that:

(a) defines system boundaries;
(b) defines what can go in and out of a system and other possible interactions between the system and the environment;
(c) states system goals, if there are any.

[93] See Section 4.2 of *Understanding Architecture* .
[94] See Section 4.4 of *Understanding Architecture* .
[95] Again, modern television weather reports that use animated synoptic charts to illustrate the development of weather patterns over periods of time perhaps provide the examples that are most commonly encountered in everyday life.
[96] See the discussion of The London Underground in Section 4.2 of *Understanding Architecture*.

Architecture views selectively emphasise different types of characteristics of knowledge about systems. However, redundancy can exist between different architecture views if their perspectives overlap [97]. Architecture views are said to be orthogonal if their perspectives do not overlap in which case there is no redundancy in the knowledge about systems that they represent.

[97] The C4ISR Architecture Framework discussed in Section 4.4 of *Understanding Architecture* provides an example of this.

Appendix F: Information Warfare and Knowledge Warfare

Philippe Baumard's paper, *'From InfoWar to Knowledge Warfare: Preparing for the Paradigm Shift'* [Baumard 1996][98], addresses how the nature of Knowledge Warfare differs from that of Information Warfare. Philippe Baumard is Professor of Strategic Management, University of Paris-XII.

Two key extracts from the paper are given below.

"Thus, it gives the illusion that the development of an information structure is a necessary and sufficient condition to attain a national knowledge infrastructure. On the contrary, such a policy will prove to be counter-productive. It will eventually create an isolated body of upper-level knowledge, disconnected with the reality of social development and learning, and therefore, increasing the gap between people who act, learn and talk, and people being acted, learned and talked." p 5

"As Wilensky once put it, "information has always been a source of power, but it is now increasingly a source of confusion. In every sphere of modern life, the chronic condition is surfeit of information, poorly integrated or lost somewhere in the system", [Wilensky 1967]. Roots of such failures can been found (a) in the persistent confusion between knowledge and information, (b) on the large-scale focus that has been given in education to cumulating of knowledge-bases vs. permanent improvement of the diversity and flexibility of modes of knowing, and (c) in the failure of scientists in integrating in new organizational forms and purposes, the advancements of social cognition and collective learning. Yet, "managers are becoming increasingly aware that informed adaptability is at a premium and to attain it they may need different modes of organization to find and solve different types of problems". Nevertheless, and consistent with a perception of knowledge as a commodity, "organization" on one side, and "knowledge' on the other side, are systematically approached distinctively. Organization theorists propose many alternatives and original organizational forms, but leave managers with the duty of generating adequate knowledge to operate them. Knowledge sociologists put much emphasis on the many forms of socializations that participate in the building of cognitive skills, but are reluctant to study how organizational design and knowledge generation interact. " p 6

[98] His paper is available at:
http://www.indigo-net.com/annexes/289/baumard.htm

Appendix G: Kasparov versus Kasparov

Appendix G is a lighted-hearted "quasi-case-study" that, by analogy, affords useful insight into the inter-dependence of information and knowledge in Knowledge Warfare. It is stressed that this is fictional example; any resemblance to real persons, living or dead, is entirely co-incidental!

Comrade Kasparov is a fanatical chess player. Furthermore, she is an avid student of the game and has studied all of the major chess texts and analysed most of the great matches between the masters in recorded history.

When her son, Gary, is born, his mother is delighted. She introduces him to the game at a very early age, taking the role of his only coach, and either oversees or takes part in every game that her boy ever plays.

At the age of four, before Gary can read, he beats his mother for the first time. In the game, since it is played according to the usual conventions, both players have exactly the same information about that specific game. Comrade Kasparov has, of course, a vastly superior experience of chess than her son. Indeed, her son has had no access to information regarding chess that his mother has not. In fact, all of his information on chess has either been provided by his mother or shared directly with her. Nevertheless, despite this apparently overwhelming disadvantage, his precocious talent has enabled him to develop knowledge of how to play and win at chess that is superior to his mother's.

This provides an example that information superiority is not necessary to win in knowledge intensive conflict. Interesting points to note are that:

- both players had identical and complete information of the game as it was played;
- Comrade Kasparov had vastly more information on chess than her son;
- Gary Kasparov had no relevant information that his mother did not.

It also provides an example that information superiority is not necessary to develop knowledge superiority. Indeed, it demonstrates that circumstances exist in which the ability to learn and to apply knowledge can be a much more important factor than access to information.

It also highlights that there is more than one type of information and that the differences between these types can be significant. In this case there are at least the following types:

- the information encoded in the DNA which the mother and child share;
- the information in the brains of the players concerning the particular game in question due to their observation of the positions of the players on the board during the progress of the game;
- the information recorded in the chess texts and match transcripts which Comrade Kasparov had read and interpreted;

- the information passed on from the mother to the son in the course of her teaching and coaching.

Finally, the case also proves that, in some cases at least, mind can prevail over *mater*!

Appendix H: Knowledge Edge

ASP97, [Defence 1997], has designated the 'Knowledge Edge' as "our highest capability development priority", It uses the term 'Knowledge Edge' to refer to "the effective exploitation of information technologies to allow us to use our relatively small force to maximum effectiveness."

Some members of the ADO have taken this clause to act as a definition of the concept of Knowledge Edge. This assumption has not been made by the author; he has preferred to assume that a fuller meaning is intended for the term than that which can be inferred from a literal interpretation of the clause.

It is suggested that the definition of Decision Superiority given COMAST's "Decisive Manoeuvre: Australian Warfighting Concepts to Guide Campaign Planning', [Defence 1998], gives a clearer insight into the nature of 'Knowledge Superiority' and, by inference, the 'Knowledge Edge'.

> '*Decision Superiority* is the concept which supports all others. Manoeuvre warfare has been described as a race against time, and Australia's limited resources and likely reactive posture at the outset make it all the more important that the ADF is an organisation imbued with the concepts of directive control, possessing a robust command, control and communications system and capable of maintaining a decision tempo faster and more effective than that of the adversary. To achieve such a tempo, the ADF must be capable of a superior use of knowledge to that of its opposition, both to support its own operations and to hinder those of its enemy. This agility of mind must, of course be matched by agility of action.'

Para 1.17
(Italics from original; Underlinings added)

In particular, it can be gathered from this that Knowledge Edge involves a difference in the capabilities of two (or more) opposing military forces in the conduct of Knowledge Warfare. This is emphasised in the following extract from 'Decisive Manoeuvre', [Defence 1998]:

> 'For *Innovation* to have the desired effects, it must be based on comprehensive knowledge of both the adversary's strengths and weaknesses and probable intent, and of our own force capabilities. There is no point in devising a brilliantly innovative course of action that is not achievable with assigned forces. Innovative courses of action must be founded on a detailed knowledge of the strategic and tactical environments to minimise the possibility of unwanted effects.'

Para 4.18
(Italics from original; Underlinings added)

Accordingly, any characterisation of the Knowledge Edge requires not just an understanding of the Knowledge Warfare capability of the ADF but also an understanding of the Knowledge Warfare capabilities of all (potential) enemy military forces.

It is suggested that profound differences could exist between the natures of the bodies of knowledge in opposing military forces. Furthermore, it is suggested that a vital feature in achieving and maintaining Knowledge Edge will be to have understandings of the knowledge in the ADF and the (potential) enemy enterprises and to know how this can be exploited.

It is strongly suggested that it should not be assumed that Knowledge Superiority necessarily follows from Information Superiority, see Appendix G. It should be emphasised that this view does not necessarily accord with US Joint Vision 2010, [DOD 1997], which places no explicit emphasis on Knowledge Superiority or Knowledge Dominance. It does, however, stress the importance of achieving "dominant battlespace awareness" through the superior use of systems of systems which harness improvements in information and systems integration technologies.

The nature of this relationship is exposed by the following extract from 'Decisive Manoeuvre', [Defence 1998]:

> 'Conflict is a dynamic process in which the results of planned actions cannot be predicted with certainty. Even the best plan will not survive the first engagement with the adversary completely intact. To be effective *Decisive Manoeuvre* requires processes in place to monitor the situation as the conflict unfolds and to be able to react to developments faster than the adversary. This requirement is enabled by *Decision Superiority*, enhanced by superior information management and ensured by *Robust Security*.'
>
> Para 3.10
>
> (Italics from original; Underlinings added)

Furthermore, it should not be assumed that Knowledge Superiority over one potential enemy implies Knowledge Superiority over a second enemy even though it is known that the second enemy does not have Knowledge Superiority over the first. (In considering this issue it may be helpful to bear in mind the metaphor of the ancient game of "Stone - Scissors - Paper". In the game, despite the fact that the Stone "blunts" the Scissors and the Scissors "cuts" the Paper, the Paper nevertheless "wraps" the Stone.)

It would seem to follow from this preliminary discussion that the Knowledge Edge is not a static and stable phenomena which can be readily achieved or even understood, but rather one that is dynamic, volatile and elusive in nature.

On the basis of what is recognised as limited information, it is suggested that a deep understanding of the nature and conduct of Knowledge Warfare, as opposed to Information Warfare, is not currently widespread in the Department of Defence. If this is the case, then it is suggested that it follows that the achievement of its highest capability development priority, namely the Knowledge Edge, will be held back by this deficiency unless appropriately redressed. It is therefore suggested that a program of work to research the nature and conduct of Knowledge Warfare and to propagate the findings of this research within the Department would be worthwhile.

The author has been led to believe that the concept of Knowledge Edge is to be re-considered in the White Paper planned to supersede ASP97.

Appendix I: System of Systems

Appendix I attempts to provide brief definitions and explanations of the main concepts relating to System of Systems and Joint Systems.

Multiple conceptions exist for the notion of system. The diversity of these different ways of thinking is reflected in the variety of definitions that have been made for the system concept. These different ways of thinking profoundly effect the practices and behaviour of their proponents when acting as individuals and as groups. The draft paper *Understanding Architecture*, [Burke 2000], discusses this in some detail and provides examples from a selection of disciplines that are often considered relevant in the Defence context.

The following two definitions are considered apposite for current purposes.

I.1 System

A system is a complex whole, [Sykes 1977]; an integrated entity of heterogeneous components that acts in a coordinated way, [Kline 1995].

I.2 System of Systems

A System of Systems is a system whose components are:

- systems;
- components of systems.

The major factors that determine the nature of a System of Systems are:

- the nature of its components;
- the nature of the interactions between these components;
- the nature of the interactions between the System of Systems and its environment.

I.3 Defence System of Systems

A Defence System of Systems is a System of Systems whose components are:

- Defence systems;
- components of Defence systems.

There is more than one school of thought regarding the nature of the components of Defence System of Systems. Arguably, the most prominent amongst these takes a purely technological view and assumes that the components can only be tangible components of physical systems. Other schools take broader views to include humans (behaving both as individuals and as groups within shared cultures) as significant components in Defence Systems of Systems. Of those that consider humans as components of Defence Systems of Systems, some treat humans as merely physical agents; others also consider more sophisticated aspects of human behaviour. For example, the human components of the System of Systems are variously considered as:

- mechanistic components;
- highly adaptive cognitive components;
- components of Culture Systems that attempt to share meaning by operating within one or more shared culture.

There is a wide diversity possible in the interactions of the components of Defence Systems of Systems. Notably, modern Information Technologies, Telecommunications Technologies and Space Technologies enable the interaction of physically remote and functionally disparate Defence systems (and components of Defence systems). The range of emergent properties of the resultant Defence Systems of Systems is enormous.

It is of particular significance that, given that appropriate components are available, the possibility is afforded of rapidly synthesising Defence Systems of Systems to "custom-fit" the requirements of specific situations of Defence significance using components that already exist.

For example, it is thus conceivable to synthesise Defence Systems of Systems whose physical components are located on land, sea, air and space platforms and are configured under the control of a Headquarters that is not co-located with any of the platforms.

I.4 Joint System of Systems (or Joint System)

A Joint System of Systems (or Joint System) is a Defence System of Systems whose components are systems or components of systems from more than one Single Force.

Defence Systems of Systems are synthesised with the intention of exploiting their emergent properties in situations of Defence significance. There is considerable diversity in the scope of requirements (for Defence Systems of Systems) that such situations create.

The components of Defence Systems of Systems may exist prior to there being any (understanding of the) requirement for that Defence system of system. If this is not the case, then the process of synthesising the Defence System of Systems involves the creation of new components. In some circumstances, such components can be may be re-used in future Defence Systems of Systems.

Appendix J: Truth and Scientific Knowledge

According to Popper, [Popper 1977], the growth of scientific knowledge takes place by the proposal of new conjectures in response to the breakdown of previous theories. Propositions deduced from the conjectures are tested, either experimentally or by observation of the world. If the tests are unsuccessful then the conjecture is refuted, but if the tests are successful, the conjecture can be tentatively accepted. The conjecture is not verified, it is merely not falsified. Thus highly tested or highly corroborated theories are dependable because they have been shown to be useful in their predictive powers in many different circumstances, but they are not necessarily true theories. Popper argues that probability alone in its classical form is an inadequate measure of this dependability. The essence of this argument is given below.

In this example, originally discussed by Blockley, [Blockley 1980] and subsequently developed by Burke, [Burke 1991], we are concerned with determining the value of the probability that Newton's laws are true.

At first, it is tempting to argue that the probability is very high, almost one. There are a large number of successful applications of Newtonian mechanics throughout science and engineering which supports the case for them being true. Because of this we may be inclined to say that the probability of the laws being true is one.

However, when we recall that modern physics, particularly relativity, has shown that there are domains in which Newtonian mechanics is grossly inadequate, we may change our minds and say that Newton's laws are probably false.

Popper would argue, however, that all this evidence does <u>not</u> succeed in showing that Newton's laws are either true or false. He would say that we do not necessarily have a true theory but rather a highly tested, confirmed, corroborated or dependable one within the context of the domains in which they have been applied successfully.

We are therefore forced to the conclusion that the probability of Newton's laws being true is very small but that the deductions that we can make from them for non-relativistic systems are highly dependable and very useful.

Burke has proposed, [Burke 1991], that the appropriate measure for the dependability of a scientific theory is a probability interval, with the lower bound of the interval representing the support for the theory being true and the upper bound representing the support against the theory being true. In most cases the bounds of the interval will not have the same value, as only imperfect, non-exhaustive checking will have been conducted.

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Martin Burke
(DSTO-RR-0173)

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DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION DOCUMENT CONTROL DATA	1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)

2. TITLE	3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION)
Thinking Together: New Forms of Thought System for a Revolution in Military Affairs	Document (U) Title (U) Abstract (U)
4. AUTHOR(S)	5. CORPORATE AUTHOR
Martin Burke	Electronics and Surveillance Research Laboratory PO Box 1500 Salisbury SA 5108

6a. DSTO NUMBER	6b. AR NUMBER	6c. TYPE OF REPORT	7. DOCUMENT DATE
DSTO-RR-0173	AR-011-473	Research Report	July 2000

8. FILE NUMBER	9. TASK NUMBER	10. TASK SPONSOR	11. NO. OF PAGES	12. NO. OF REFERENCES
N8316/22/6	JNT 99/018	DGC3ID	114	97

13. URL ON WORLD WIDE WEB	14. RELEASE AUTHORITY
http://www.dsto.defence.gov.au/corporate/reports/DSTO-RR-0173.pdf	Chief, Information Technology Division

15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT

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16. DELIBERATE ANNOUNCEMENT

No limitations

17. CASUAL ANNOUNCEMENT Yes

18. DEFTEST DESCRIPTORS

Thought Warfare and Anti-Warfare
Thought Systems
Culture Systems
Meaning
Military strategy
Thinking
Human information processing

19. ABSTRACT

The notion of Thought Warfare and Anti-Warfare (TWAW) is introduced as a way of thinking about military conflict and its avoidance; it is foreseen as an increasingly important Defence issue in the twenty-first century. TWAW involves the dynamic interaction of allies' and adversaries' Thought Systems. Current Thought Systems involve entities capable of cognition, emotion and volition - typically (groups of) people - interacting via networks of information and data systems. New forms of Thought System are proposed that go beyond this; if realised they could provide significant comparative advantage in TWAW and may contribute to a Revolution in Military Affairs.